Report of the President
1980-81

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We must...preserve research and education as complementary activities on this campus. Indeed, I would say that the blending of research and education defines MIT, and our future must continue to rely on these combined strengths.

-- September 26, 1980

Last fall, in accepting the stewardship of MIT for the coming years, I spoke of the importance, indeed the necessity, of our future course proceeding from our historical strengths. I am struck by the difficulty of predicting the shape of the future that we ourselves are building, but recent changes in the political and economic climate that bear on our educational and research programs convince me that the surest path for MIT's continued vitality and leadership begins with being true to ourselves.

This does not mean that we reject new directions or ideas. On the contrary. Our tradition requires a continuing self-assessment and testing of concepts -- as an institution and as individuals. Indeed, this is the hallmark of our educational and research programs, and of their special synergy. In the classroom, "old" truths and principles are continually freshened and recast by the infusion of research perspective (and results) into the curriculum. The engagement of students in research activity as an essential part of their educational development brings substantive benefits to research programs as well. Students, undergraduate as well as graduate, bring to research activities the vigor and enthusiasm of youth, and the matchless advantage of fresh perspectives and new insights -- the advantage of not knowing "it cannot be done that way." A principal reason for the historic vitality of programs of basic and applied research conducted in American universities is the coupling, in the university setting, of education and research, and the constantly renewed "yeast" which is provided by the association of students with research activities. The synergism of this association is, for MIT, a source of great strength.

It is this strength, and the engagement of the faculty in the full range of MIT's academic enterprise, that will best serve us in planning for our future. The research programs and the scholarly environment at MIT spring, fundamentally, from the intellectual interests and passions of our faculty. And the educational program draws heavily on the intellectual environment which is sustained by these research programs.

In this regard, the appropriate role for the central administration is to nurture an academic environment in which individual initiative and desires can flower. Our role is one of lighting, rather than choosing, the path. While we may participate in defining and appraising alternatives for the investment of human energy and institutional resources, we should not attempt to determine the outcomes. Our concern should be to keep the metabolism of MIT in balance -- working with the faculty, the staff, and the students to preserve and enhance MIT as a place of stimulation, opportunity, and fulfillment for all who study and work here.

As I reflect on the past year, I note a number of extraordinary efforts to preserve or enhance the academic life of this place -- some having to do primarily with education, some with research, and some, of course, with both.

EDUCATION

To succeed in our educational mission we must endeavor to bring students to intellectual independence -- to the state in which they can respond effectively to intellectual novelty and can proceed
both to form meaningful questions and to seek informative answers in situations which go beyond their prior experience and formal education. The development of this capacity is surely our most important educational goal. Students who have reached this threshold of intellectual independence have the ability to educate themselves throughout their lives -- lives which will be characterized by continuing change and by needs for understanding, knowledge, and wisdom which transcend our imaginings and dreams.

While the responsibility for graduate education rests primarily with the individual academic departments, the undergraduate program -- as reflected in the General Institute Requirements -- represents a shared sense of purpose among the faculty for the education of our students. In this respect, the undergraduate program is a major unifying force at MIT, one which opposes the centrifugal forces associated with the independent development of departments and disciplines.

The faculty's commitment to providing our students with an education which will sustain their personal and professional development has been much in evidence during the past year. Led by Professor Sheila E. Widnall, the Chairman of the Faculty for the past two years, the Committee on Educational Policy has begun an intensive and wide-ranging review of issues affecting undergraduate education, a review which draws on the wide participation of faculty and students throughout the Institute. This review, the first in nearly a decade, is focused both on curriculum structure and content, and on less tangible issues related to pace, pressure, and other elements of "the hidden curriculum."

The review encompasses three basic areas:

- The science requirements;
- The requirement in the humanities, arts, and social sciences;
- The intellectual climate experienced by undergraduate students.

The CEP -- and its various working groups -- is in the midst of appraising these and related issues. Nevertheless, a few early observations may be in order, both as an indicator of directions and as a precursor of the discussions among faculty and students which will continue during the coming year.

With regard to the Institute science requirements, the Committee has examined the scope and content of the first-year subjects in physics and mathematics -- and has reaffirmed these subjects as important foundations for the interests of most of our students. More serious questions are being raised about the nature and educational consequences of the science distribution requirement and the laboratory requirement, and the Committee is considering significant changes in both requirements. They are also exploring the possibility of adding an Institute requirement in the area of the life sciences. Additions to the core program are not undertaken lightly -- and must take into account the balance between the core program and the departmental program, and the importance of intellectual exploration not bound by requirements. The CEP is quite mindful of these considerations, which must be balanced against the expanding and central ground of biology and the life sciences where the intellectual excitement associated with fundamental discoveries concerning the molecular basis of life is matched by the growing applications of revolutionary techniques such as gene splicing.

The Institute requirement in the humanities, arts, and social sciences is also under review by the CEP. The issue of balance in students' programs among these three areas of study is of concern, as is the manner and basis on which this requirement is administered by the faculty.

Another major area of concern (and one shared by most faculty and students) is the level of writing proficiency among our students. The ability to organize and communicate one's ideas to others is a simple and fundamental measure of an educated person. At MIT, as throughout the country, there has been a marked decline in the literacy of our entering students. The CEP's preliminary view is that this problem requires both early diagnosis and a variety of writing opportunities in order to improve and to enhance our students' ability to write clearly and well. The Committee feels, too, that this problem is of concern broadly to the Institute, and must be addressed from an institutional as well as a departmental perspective.
In considering the educational consequences of the pace of the Institute, I recall my own observation last September:

This union between committed hard-working people and an institution in which hard work is a deeply ingrained ethos produces, all too often, a frenetic pace of life -- a pace which is self-rewarding and mutually reinforcing. And not without its costs... Should we not ask from time to time about the side effects of this high-pressure environment? And should we not consider the possible benefits of more time for contemplation, for pursuit of interests and activities outside the professional realm, and for developing friendships and a sense of community?

The CEP is examining ways in which the formal structure of undergraduate programs, and the traditional accounting for academic progress may contribute to a frenetic pace at the Institute. Among these concerns are: constraints on academic choice (in the freshman as well as later years) brought about by departmental degree requirements; the current system of counting credit units which suggests that there is meaning and precision in the way we record differences in the value, and the effort required, of different subjects; and the influence of grading and registration policies on students' tendencies to register for a remarkable number of subjects early in the term, only to drop some of them at the end of the semester -- a practice which seems to place the value of a respectable transcript ahead of sound and balanced intellectual achievement.

Issues of pace and pressure are intimately related to the culture of this place. The CEP is addressing some of the major cultural consequences of our academic program; there are other aspects of life at MIT which might well be addressed by other groups. While it is exceedingly difficult to develop a full understanding of that culture and its consequences, let alone to devise effective strategies for change, these are issues which deserve our continuing and careful attention.

This review places heavy demands for time and energy on the CEP and other faculty and students who are engaged in the task. All members of this academic community are indebted to them. I am particularly grateful to Professor Widnall, who has so ably organized this review of undergraduate education and established it on a footing which will carry it, under different leadership, to conclusions and recommendations for action in the year ahead.

The future vitality of undergraduate education at MIT depends as well on our ability to continue to enroll students of high quality and ability, who reflect diverse backgrounds and interests. Several aspects of this imperative require our continued attention and concern:

• The number of young people who have been prepared by their prior school experiences for study in science-based programs such as those offered at the Institute has decreased in recent years, and this trend continues. We have witnessed not only a general decline in the rigor of secondary school programs, but a particular decline in the quality of science education. The national concern with the quality of secondary school education in science and mathematics, which began 25 years ago, has waned. Indeed, it has been replaced by a shocking degree of antipathy for science even as the impact of science and technology on our lives increases. The decline in scientific literacy can be seen in lowered college entrance examination scores and in the decreasing number of high school graduates who have studied mathematics and science for more than one year. Where, in an age in which science and technology will play increasingly important roles in our society, will we find the young people who have the capacity and the desire to provide leadership and creativity in science and technology, or who have educations of sufficient breadth to enable them to participate effectively as citizens in discussions involving the impact of science and technology on their lives?

• We are committed to the development of a student population which reflects in its diversity the richness of our society. We have a responsibility to be open -- and to reach out -- to the most promising and talented people, regardless of race or sex. The Institute has made significant progress in the past decade in increasing the number of women who enroll; fully one-quarter of the Class of 1985 are women -- the highest in our history.

The situation with respect to minorities gives less reason for encouragement. The fraction of Black, Hispanic, and Native American students in the undergraduate student body, while it has increased somewhat, is still around eight percent, and the fraction in the graduate student
body has actually declined somewhat since 1975. The number of these young people who continue their graduate studies through the doctorate remains distressingly small. While MIT is not alone in these experiences, we have an obligation for leadership in this area which requires that we invent new ways of reaching those highly gifted people whose capabilities we have not fully tapped and whose talents we have not previously nurtured.

* The costs of running -- and therefore, attending -- the Institute have risen rapidly in recent years. Today, more than half of our undergraduates, and even more of our graduate students, are dependent on financial aid for meeting the costs of an MIT education. For most, this means some reliance on loans -- loans which will be more difficult to obtain given recent decisions by the Federal government regarding student financial aid programs. The eligibility restrictions on the Guaranteed Student Loan Program, as well as the freezing of funding levels for grants, fellowships, and work-study programs, portend an uncertain future for the concept of equal educational opportunity.

We can only speculate about the effect of these changes on interest in and access to the high-cost selective universities. Preservation of access for individuals from all economic levels of the society clearly requires availability of financial aid which matches the costs of these institutions. But none of these institutions, MIT included, has the resources to replace the financial aid which comes now from Federal programs. Curtailment of those programs will create difficult and painful choices for both educational institutions and future generations of students.

These, then, are some of the primary factors affecting students' interest in and ability to attend MIT. And they will have much to do with the kind of institution we will be in the future.

Beyond the question of who comes to MIT is the question of who stays. It is not enough to enroll the brightest students from a broad spectrum of circumstances and cultures. We must encourage and support their growth as individuals and as members of a culturally diverse community -- so that every student who enters here regards MIT not as a challenge to overcome but as an opportunity for personal and intellectual fulfillment.

RESEARCH

Since the end of the Second World War, American universities have been the locus of most of the basic research in the United States, and the Federal government has been the sponsor and patron of nearly all of that research. That historic Federal role came about, first, because no other organization or agency has the resources or the sustained interest required to nurture a broadly based program of basic research which was of general benefit to the entire nation. In addition, that sponsorship stemmed from government recognition of the benefits derived from the association of education and research, and its desire, therefore, to encourage graduate study in science and engineering.

During the past dozen years, Federal support of university research has changed significantly -- in ways which have made it increasingly difficult for many universities to preserve and sustain their programs in research and graduate education. Among these changes are the following:

* a plateau in Federal financial support (in real dollars) of university research between 1969 and 1976, and only a modest improvement since that time.

* negligible support for research facilities and instrumentation for the past decade or more -- a time when the cost (as well as the capabilities) of instrumentation has increased dramatically. As a result, the quality of the instrumentation in academic laboratories is simply not up to the standard now found routinely in high-grade industrial settings.

* a substantial reduction in Federal support for fellowships and scholarships for graduate students (from 735 students in 1970 to 292 students in 1980 at MIT alone).

When the Federal government became heavily involved in the support of university-based research (and graduate education) more than 30 years ago, the relationship was construed on both sides as a partnership, in which the partners were pursuing shared objectives in the national interest,
and would act in ways which were mutually supportive. In recent years, that relationship has devolved increasingly toward one of arm's length negotiation, or at times, toward one of adversarial antagonism. Several indicators of this change might be mentioned:

- The individuals in government and in the universities who were instrumental in shaping the relationship at the outset have retired or otherwise disengaged, and there has been a significant loss of experience and understanding of the basic premises of that partnership.

- There has developed in the Congress and in the public mind a strong expectation of greater accountability, in the narrow financial sense, by universities for their stewardship of Federal funds. In the government's press toward more stringent accountability, universities are frequently regarded, implicitly if not explicitly, as just like any other Federal contractor. This posture recognizes neither the natural and highly beneficial coupling between education and research, nor the special trust which universities hold for the enhancement of individual initiative as well as for the broad public good.

- There has also developed in the Federal government a concern over access to research which may bear on this country's military or commercial security. The concern may well be legitimate, but the regulations developed in the past few years, and their potential application, would restrict access to certain types of research in ways that would undermine the basic premise of the university as an arena for free and open inquiry.

- As Federal budgets for research have fallen, grants and contracts have decreased in size (as opposed to number), and the research which is supported has become more limited in scope and in duration. As a result, the ratio of "overhead" -- both intellectual and organizational -- to direct research effort has increased, and members of the faculty and research staff spend relatively more energy in the tasks of seeking, reporting on, and renewing research support. This change, accompanied by a steady increase in the formal regulation of university activities, has produced a profound change in the ways in which researchers use their time and energy.

It would be foolish to argue for a return to halcyon days in this time of continuing skepticism about science, technology, and, indeed, about higher education -- a period in which Federal expenditures are under great political pressure. Nevertheless, it seems to me that the research universities must rethink and make more persuasive the arguments for greater support of research and graduate education. We must accept the call for greater accountability, as a practical necessity, while at the same time insisting that the mechanisms of accountability reflect the reality of the university setting, and do not impair research or education. While it is not possible to turn back the clock, I believe it is both desirable and possible to redefine and reestablish a vigorous and mutually supportive relationship between the Federal government and the research universities.

At the same time that the relations between universities and government are being recalibrated, there is growing support of university research by industry. While the absolute level of such support is still small -- about three percent of university-based research in 1979-80 was industrially supported -- it is growing. (At MIT the volume of industrially sponsored research has doubled in the past two years and now stands at about 10 percent.) The vitality of such support is demonstrated by several substantial industry-university research programs announced recently. These include the microelectronics program at Stanford University (supported by a number of corporations with interests in electronics), the DuPont-sponsored program in molecular genetics at Harvard Medical School, and the program in combustion research sponsored at MIT by Exxon Research and Engineering. These programs have stemmed from industrial sponsors' wishes to have more intimate access to universities as sources of knowledge and graduates, and from the research universities' need for additional sources of long-term support for important areas of research and graduate education.

The expansion of corporate support of research in universities has been accompanied by expressions of concern in the media and in the Congress. That concern seems to center on the perception that industrial research sponsors will receive privileged access to facilities which have been supported by public funds and that there will be restrictions on access to industrially sponsored research -- restrictions which will curtail the public utility of this research. In other words, if private support of university-based research is encouraged, the public will have to "buy back" what should be, in the first place, public property.

Another related concern (and one that is shared by some university colleagues) is that the nature of the research will be constrained or biased by the industrial sponsor. It is true that industrial
sponsors are likely to have a stronger interest in developing the practical consequences of
research. But I have seen no evidence that the relatively greater interest by corporations in
supporting applied research is a corrupting influence on the conduct of research in universities.

In short, I believe that these perceptions reflect a misunderstanding of the history and the nature
of the relationship between universities and industrial sponsors.

Universities are, and must remain, open organizations in which the sharing and free flow of
information is the norm. Every faculty member must be free to discuss his or her work with
colleagues, the research of each student must be open to the scrutiny of all interested parties,
and the results of research must be available in the open literature.

These principles are not inconsistent with the practices which, in our experience, have usually
arisen in research agreements with industry. In general, I have found corporations to be en-
couragingly sensitive to the need to honor the essential freedoms of the universities and our
obligation to pursue the truth without distortion by outside interests. We must continue our
steadfast support of the principles of open inquiry and exchange of knowledge, but I do not
believe that these issues will be more pressing or that the intellectual climate will be less open
when the sponsor of the research is a private corporation rather than the Federal government.
Indeed, we welcome suggestions from private corporations on how we might mutually benefit from
the new Congressional bill providing tax credits for industrial support of academic research or
fairer tax treatment for donations of equipment for research.

Industrial sponsors, as noted above, do have a keen interest in developing novel ideas which
result from research. This interest provides a primary means of transferring the practical
benefits of academic research to a broad population. Patenting of inventions which result from
sponsored research and issuing licenses to permit the use of those inventions are essential com-
ponents of the process of technology transfer. It is sometimes believed that unpatented inventions
which enter the public domain through publication form the basis for the widest possible use of
new technology. This idea ignores the substantial additional work and investment which is
necessary if a new idea is to be developed into a marketable product -- work and investment
which usually occurs in the private sector of our economy. If a corporation is to commit the re-
sources to develop a promising idea into a useful product or service, it is reasonable to seek the
protection of a patent and, if the risks seem high, to require a limited period of exclusive licens-
ing to improve the likelihood that its investment in developing an idea will be recovered.

The concern that industrial sponsorship of research somehow gives private interests access to a
public good reflects, as well, a lack of understanding of the historic role which corporate philan-
thropy has played in the development of the major private research universities. It is simply
not the case that these institutions have been built and developed principally with Federal funds.
Whether one speaks in terms of academic buildings, in terms of endowment, or in terms of the
annual gifts which are of such crucial importance to the universities, private financial support --
much of it provided by private corporations -- is the sine qua non. In a very real sense the
Federal government buys a bargain when it supports research and education in universities
because these institutions have become what they are as a result of private support.

Federal support of the research program is, as I have indicated earlier in this report, essential
as well. Perhaps the most accurate description of the development and operation of the research
universities is one which focuses on balance, with both government and the private sector acting
as vital partners in our endeavors.

These, then, are some of the major concerns which have highlighted the past year, and which
bear directly on the quality of life for our faculty, students, and staff. In order to maintain the
special character and advantages of MIT, we must look carefully at our resources, our priorities,
and our goals, and build our future on a shared understanding of the kind of institution we are
and want to be. This will require intense discussion among all of us here and, at times, difficult
choices among worthwhile goals. But just as MIT's strength rests in the synergy of its education
and research, so too does it rest in the commitment of its members to the institution as well as
to the individual fields and interests it encompasses. I can think of no better foundation for
our future.
In Special Recognition

The special character of MIT is reflected each year in the achievements and honors of its faculty. In this part of the report, tribute is given to many of those whose accomplishments highlighted the year.

This past winter, three members of the MIT faculty were elected to membership in the National Academy of Engineering. Their election brings to 62 the number of MIT faculty who have been chosen for membership in the prestigious national engineering organization. The faculty members are: C. Allin Cornell, Professor of Civil Engineering; Elias P. Gyftopoulos, Ford Professor of Engineering, who has appointments in the Department of Mechanical Engineering and the Department of Nuclear Engineering; and James W. Mar, Jerome C. Hunsaker Professor of Aerospace Education. Professors Gyftopoulos and Mar are MIT alumni. Sixteen other alumni also were elected.

In the spring, three members of the faculty were elected to the National Academy of Sciences, in recognition of distinguished achievements in original research. The three new members are: George B. Benedek, Alfred H. Caspary Professor of Physics; David Botstein, Professor of Genetics in the Department of Biology; and Daniel L. McFadden, Professor of Economics. Professors Benedek, Botstein, and McFadden bring to 81 the number of MIT officers and faculty, active and emeriti, who are members of the Academy.

In May, four members of the MIT faculty and one research staff member were elected to the American Academy of Arts and Sciences. They are: Hermann A. Haus, Elihu Thomson Professor of Electrical Engineering; Norman C. Rasmussen, Professor and then Head of the Department of Nuclear Engineering; Stanley Fischer, Professor of Economics; Loren R. Graham, Professor of the History of Science; and Nelson Y. S. Kiang, a member of the research staff of the Research Laboratory of Electronics.

In January, Frank Press returned to MIT as Institute Professor, following his years of service in Washington, DC, as science advisor to President Carter and director of the White House Office of Science and Technology Policy. He remained at the Institute during the spring term, before taking up new responsibilities as president of the National Academy of Sciences.

Earlier in the academic year, two MIT faculty members were elected to the Institute of Medicine. The two are: Ernest G. Cravalho, Matsushita Professor of Mechanical Engineering in Medicine, Associate Director of the Whitaker College of Health Sciences, Technology, and Management, and Associate Director of the Harvard-MIT Division of Health Sciences and Technology; and Maurice S. Fox, Lester Wolfe Professor of Molecular Biology. Members are chosen for their contributions to health and medicine or to related fields such as the social and behavioral sciences, law, administration, and engineering. The election of Professors Cravalho and Fox brings MIT's membership in the Institute of Medicine to a total of 10.

Also in the fall, Phillip A. Sharp, Professor of Biology, was chosen as the 1980 recipient of the American Chemical Society's prestigious Eli Lilly Award in Biological Chemistry. The award, which was established in 1934, is given annually to a scientist under age 36 who has accomplished outstanding research in biological chemistry.

In February, Dr. Charles Stark Draper, Institute Professor, Emeritus, and Professor Emeritus of Aeronautics and Astronautics, was inducted into the Inventors Hall of Fame. Dr. Draper -- who has been associated with MIT as a student and as a faculty member for almost 60 years -- was inducted into the Hall of Fame for his invention of inertial guidance, which is the concept that makes possible the precise navigation of spacecraft and aircraft. Only 34 inventors have been so honored since the establishment of the Hall of Fame in 1973.

Within the Institute, Chia-Chiao Lin, Institute Professor and Professor of Applied Mathematics, was selected by faculty colleagues to be the 1981-82 recipient of the James R. Killian, Jr., Faculty
President

Achievement Award. The Award recognizes extraordinary professional accomplishments and service to the Institute. The Award citation reads, in part "... C. C. Lin has repeatedly made seminal contributions of both theoretical and applied significance. His work... and the style he represents, has been an inspiration to colleagues in many departments of MIT... Perhaps no other faculty member enjoys so broad a sphere of influence among neighboring faculties...."

Also during the year, Professor Morris Halle was appointed Institute Professor -- an honor bestowed by the faculty and administration on a faculty colleague who has demonstrated exceptional distinction by a combination of leadership, accomplishment, and service in the scholarly, educational, and general intellectual life of the Institute or wider academic community. Professor Halle's appointment recognized his leadership in linguistics as well as his studies of literary form, acoustics, physiology, and psychology.

Several changes in senior posts in the academic administration were announced during this past year. These changes include the selection of three new academic deans: Abraham J. Siegel as Dean of the Sloan School of Management (succeeding William F. Pounds), Jean P. deMonchaux as Dean of the School of Architecture and Planning (succeeding William L. Porter), and Gerald L. Wilson as Dean of the School of Engineering (succeeding Robert C. Seamans, Jr.). Dean Siegel, who had served as Acting Dean of the Sloan School since July 1980, took up his new responsibilities in June. Deans deMonchaux and Wilson assume their posts on September 1. New department heads announced during the year include William F. Brace, Department of Earth and Planetary Sciences (effective July 1, 1981); James W. Mar, Department of Aeronautics and Astronautics (effective July 1, 1981); Peter H. Stone, Department of Meteorology and Physical Oceanography (effective July 1, 1981); Joseph M. Sussman, Department of Civil Engineering (effective September 1, 1980); and Neil E. Todreas, Department of Nuclear Engineering (effective July 1, 1981).

Other changes in the academic administration announced during the year included the appointment of Jerome I. Friedman as Director of the Laboratory for Nuclear Science; Carl Kaysen as Director of the Program in Science, Technology, and Society; Sanjoy K. Mitter as Director of the Laboratory for Information and Decision Systems; and Jonathan Allen as Director of the Research Laboratory of Electronics, succeeding Peter A. Wolff who becomes Director of the Francis Bitter National Magnet Laboratory.

Several changes in senior administrative posts also occurred during the year. These include Fernando J. Corbató as Director of Computing and Telecommunications Resources in the Office of the Provost; Jack H. Frailey as Director of the new Office of Student Financial Services (which links the Student Accounts Office, the Office of Student Financial Aid, and the Student Loan Office); William J. Hecht as Executive Vice President of the Alumni Association; and Clarence G. Williams as Acting Director of the Office of Minority Education. William R. Dickson, Vice President for Operations, has undertaken added new responsibilities for oversight and coordination of the responsibilities of the administrative vice presidents. Kathryn W. Lombardi, Manager of Campus Information Services, accepted additional responsibilities as Executive Assistant to the President.

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

Dwight C. Arnold, a member of the Class of 1927, and former Corporation member, died in November at the age of 75. An active alumni leader throughout his life, Mr. Arnold was president of the Alumni Association in 1955-56.

In September 1981, William A. Baker, Curator of the Francis Russell Hart Nautical Museum at MIT for 18 years, died at the age of 69. Mr. Baker, who also served as part-time lecturer in the Department of Ocean Engineering, was the designer of the Mayflower II and dozens of other replicas of historic ships.

In February, James A. Beattie, Professor of Physical Chemistry, Emeritus, died at the age of 85. An MIT alumnus, Professor Beattie was a member of the MIT faculty for 38 years, and continued his work in thermodynamics well after his retirement in 1961.

Jule G. Charney, former Head of the Department of Meteorology and Physical Oceanography, died in June, at the age of 64. A major world figure in the fields of dynamic meteorology and oceanography, Professor Charney had been a member of the MIT faculty for 25 years.
In November, Margaret Hutchinson Compton, a cherished member of the MIT community for half a century, died at the age of 88. Widow of MIT's ninth president, Karl Taylor Compton, her contributions to the sense of community and pride of citizenship in the Institute enriched us all.

Cecil G. Dunn, Associate Professor of Industrial Microbiology, Emeritus, died in August 1981, at the age of 77. A 1930 graduate of MIT, Professor Dunn was the coauthor with the late Dr. Samuel C. Prescott of the original edition of *Industrial Microbiology*.

Marcy Eager, Associate Professor of Electrical Engineering, Emeritus, died in April at the age of 82. A member of the MIT community for over 25 years, he served not only as a faculty member but was active for many years in the administration of the Electrical Engineering Cooperative Program.

James B. Fisk, a member of the MIT Corporation for 22 years and of its Executive Committee for 19 years, died in August 1981, at the age of 70. An internationally respected physicist who had headed Bell Telephone Laboratories for 14 years, he served as a trusted advisor to all of the presidents in MIT's modern history.

In July 1981, Thomas F. Jones, Jr., MIT's Vice President for Research since 1975, died at the age of 65. One of the nation's leading engineering educators and administrators, his influence on generations of students and teachers is immeasurable, and his passing is felt keenly by all who benefitted from his friendship, wisdom, and enthusiasm for life and learning.

In November, a devoted alumnus and member of the Corporation, Ellis C. Littman and his wife Roslyn, were killed in the MGM Grand Hotel fire in Las Vegas. Both Mr. and Mrs. Littman were active and generous supporters of the Institute and of the Alumni Association for many years.

William A. Martin, Associate Professor in the Department of Electrical Engineering and Computer Science and in the Sloan School of Management, died in June at the age of 43. His work -- computer programs embodying various forms of mathematical, medical, management, or linguistic expertise -- found wide practical use throughout the country.

George C. Newton, Jr., Professor of Electrical Engineering, died in April at the age of 61. A member of the MIT faculty for 34 years, Professor Newton devoted much of his energy to the service of the Institute as well as to his teaching and research on control systems and devices.

Shannon Curtis Powell, Professor of Naval Architecture and Marine Engineering, died in August 1981, at the age of 66. An MIT alumnus, Professor Powell was a member of the faculty from 1948 to 1976, and was known for his teaching and research in marine propulsion systems.

PAUL E. GRAY, President
Statistics for the Year

The following paragraphs report briefly on the various aspects of the Institute's activities and operations during 1980-81.

Registration

In 1980-81 student enrollment was 9,365, compared with 9,053 in 1979-80. This total was comprised of 4,577 undergraduates (compared with 4,517 the previous year). Graduate students who entered MIT last year held degrees from 379 colleges and universities, 220 American and 159 foreign. The international student population was 1,829, representing 10 percent of the undergraduate and 29 percent of the graduate population. These students were citizens of 95 countries.

Degrees awarded by the Institute in 1980-81 included 1,106 bachelor's degrees, 1,012 master's degrees, 72 engineer's degrees, 395 doctoral degrees -- a total of 2,585.

The number of women at MIT, both graduate and undergraduate, has continued to increase. In 1980-81, there were 1,737 women students (891 undergraduate and 846 graduate) at the Institute, compared with 1,565 (806 undergraduate and 759 graduate) in 1979-80. In September 1980, 255 first-year women entered MIT, representing 23 percent of the entering class.

In 1980-81, there were 779 minority students (611 undergraduate and 168 graduate) at the Institute, compared with 771 (579 undergraduate and 192 graduate) in 1979-80. The first-year class entering in September 1980 included 180 minority students, representing 16 percent of the class.

Student Financial Aid

During the academic year 1980-81 the student financial aid program was again characterized by increases in the overall need for financial aid, and in the aggregate amount of grants made available. There was a decrease in the amount of MIT loans awarded, and a large increase in loans obtained from commercial sources.

A total of 2,302 undergraduates who demonstrated the need for assistance (50 percent of the enrollment) received $7,959,213 in grant aid and $2,390,441 in loans. The total, $10,349,654, represents an eight percent increase in aid compared with last year.

Grant assistance was provided by the scholarship endowment in the amount of $2,442,048; by outside gifts and Federal allocations to MIT for scholarships in the amount of $1,545,975; and by direct grants to needy students totaling $2,381,372 (almost the same amount as last year). Scholarship assistance from MIT's own operating funds was provided to the extent of $1,455,000 (nearly three times last year's level and the largest allocation ever). The special program of scholarship aid to minority group students represented an additional $120,954 from specially designated funds. An additional 417 students received 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 $1,190,376 (four percent) and which raised the principal of the endowment to $29,411,212.

Loans totaling $2,390,441 were made to needy undergraduates -- a four and one-half percent decrease from last year. Of this amount, $299,184 came from the Technology Loan Fund and $2,091,257 from the National Direct Loan Fund. Not included in the foregoing summary is an additional $5,445,613 obtained by undergraduates from state-administered Guaranteed Loan

* Minority students include Blacks (non-Hispanics), Native Americans (including Alaskan Natives), Hispanics, and Asians or Pacific Islanders.
Statistics for the Year

Programs and other outside sources. This represents a 54 percent increase in the use of these programs over last year.

Graduate students obtained $400,905 from the Technology Loan Fund, nearly all of which was loaned to international students and did not qualify for the Federal interest subsidies and guarantees available under the Guaranteed Loan Program. In addition, $58,225 was loaned from the National Direct Student Loan Program. The total, $459,130, represents a significant reduction (65 percent) compared with last year's level, but graduate students obtained $4,084,985 from outside sources, under the Guaranteed Student Loan Program -- a 66 percent increase over last year. The total loaned by MIT to both graduate and undergraduate students was $2,849,571, a decrease of 18 percent from last year's total.

Career Planning and Placement

For the third year in a row demand for the Institute's graduates was exceptionally strong. A total of 406 companies and government agencies came to interview students in the Office compared with 404 a year ago and 409 in 1978-79. There have been only two other times since the Second World War when there have been such sustained spells of recruiting activity: between 1955 and 1958 and again between 1965 and 1968. At the end of the academic year, however, there were signs that the market might be slackening. There was less demand from the semiconductor industry, some computer companies reduced their hiring, and there was hesitation on the part of a number of industries dependent on capital spending. At the same time, many firms are asking how they can attract a larger share of MIT talent and the Office's recruiting facilities are already fully booked for a number of weeks in the coming year.

Although the demand remained strong, fewer students asked to have their resumés circulated to companies and fewer signed up for interviews. Five hundred forty-five students submitted resumés for the two-volume resume book which the Office publishes serially in September and December, compared with 747 the year before. The number of students having interviews dropped by a comparable amount, to 1,417 from 1,741. However, individuals had more interviews, with the result that the total of student interviews -- 8,330 -- was close to the previous year's total of 8,476. Including interviews by postdoctoral fellows, alumni, and others, the total of interviews was even higher than the record figure of the previous year: 8,797 in 1980-81 compared with 8,718 in 1979-80.

Salary offers in science and engineering rose as fast or faster than inflation. The average starting salary of master's graduates at the Sloan School rose seven percent to $34,200. Doctor's degree recipients in electrical engineering, who received an average offer of $34,620, were the only technical graduates who were better paid.

Finances

The Institute's operating budget was in balance for the fifth consecutive year. 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 1979-80. Education and general expenses -- excluding the direct expenses of departmental and interdepartmental research, and the Lincoln Laboratory -- amounted to $197,440,000 during 1980-81, compared to $163,056,000 in 1979-80. Reflected in the finances of the Institute was the use in operations of unrestricted funds of $6,863,000, compared with $5,792,000 in the preceding year.

The direct expenses of campus departmental and interdepartmental sponsored research increased from $124,296,000 to $138,345,000; the direct expenses of the Lincoln Laboratory's sponsored research increased to $138,068,000 from $127,347,000 because of an overall increase in government research support.

The construction program of the Institute continued to make progress in 1980-81 with the book value of educational plant facilities increasing from $230,488,000 to $262,658,000.

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 $442,114,000 and a market value of $579,875,000. This compares to book and market values of $396,662,000 and $507,471,000 last year.
Statistics for the Year

Staff awards for tuition
Statistics for the Year

Gifts

Gifts, grants, and bequests to MIT from private donors increased significantly to a total of $42,934,000 in 1980-81, compared with $33,841,000 in 1979-80. The 1980-81 figure includes unrestricted direct gifts to the Alumni Fund of $3,000,000, which constituted part of the total $7,287,000 reported by the Alumni Fund in 1980-81.

Physical Plant and Campus Environment

During the year, construction continued at the highest level since the major facilities expansion of the 1960-70 decade. The Athletics Center was completed in September 1980. The dormitory at 500 Memorial Drive, the Whitaker College of Health Sciences, Technology, and Management/Health Services complex, the renovations in the Sloan School, the renovations at 70 Memorial Drive for use by the College of Science, Technology, and Society and the Sloan School, and the renovations at One Amherst Street for use by the Energy Laboratory and a variety of other programs are all scheduled to be completed in the summer and fall of 1981.

Other renovation projects completed during the year were the George R. Harrison Spectroscopy Laboratory in Building 6, an addition to the Plasma Fusion Center in Building NW16, the Aga Khan Islamic Architecture facility in Building 10, and major space for the Department of Architecture in the former Epsco Building on Massachusetts Avenue at the north side of the campus.

This year's freshman class was the first to participate in the new dining program initiated this past fall. The implementation of this plan, as proposed by the Committee on Campus Dining, proceeded on schedule with no major problems. The acceptance of the use of the control system, the efforts of the House Commons Committees, the Dining Advisory Board, and the support and efforts of the students and employees contributed to a high level of success. Several food service-related studies were also initiated during the year, including one by Arthur D. Little, Inc., which conducted a general evaluation of Food Services' operations. Their conclusions and recommendations were useful in the overall implementation of the dining program.

The architectural firm of Goody, Clancy and Associates, Inc., was selected to study the facilities at Walker Memorial, specifically those relating to dining. The purpose of this study is to define a means of providing separate dining facilities for the students on the east side of campus which would allow them to conduct dining-related programs without being infringed upon by the rest of the community using the dining services in Morss Hall. A preliminary report is expected early next year.

Finally, the dining services in McCormick Hall were reopened this year after being closed since 1972.
Personnel Changes

CORPORATION

DEATHS
Ellis C. Littmann
Member
James B. Fisk
Life Member

FACULTY

DEATHS
Jule G. Charney
Professor in Department of
Meteorology and Physical
Oceanography
Thomas F. Jones
Vice President for Research and
Professor of Engineering
David C. Marr
Professor in Department of
Psychology
William A. Martin
Professor in Department of
Electrical Engineering and Computer
Science
George C. Newton, Jr.
Professor in Department of
Electrical Engineering and Computer
Science

RETIREMENTS
Ross H. Smith
Special Advisor for Athletic
Resources in the Office of the
President
Gerald P. Dinneen
Professor in School of Engineering

RESIGNATIONS
Institute Professors
Frank Press

Associate Professors
James M. Becker
Civil Engineering
Gary L. Lilien
Sloan School of Management
Michael O’Hare
Urban Studies and Planning
Arthur P. Solomon
Urban Studies and Planning
Charles B. Thorn
Physics
Langdon Winner
Program in Science, Technology, and Society

Assistant Professors
George E. Abouseif
Mechanical Engineering
Thomas Antonsen
Physics
Gregory R. Baker
Mathematics
Carliss Y. Baldwin
Sloan School of Management
Ilona Bell
Humanities
William M. Bowles
Aeronautics and Astronautics
Antonio DiMambro
Architecture
Reinaldo Gomez
Nutrition and Food Science
Steven K. Gregory
Architecture
Theodore C. Landsmark
Urban Studies and Planning
Yue-Ying Lau
Mathematics

DEATHS
Ellis C. Littmann
Member
James B. Fisk
Life Member

RESIGNATIONS
Gregory Anrig
Member, Ex Officio

CHANGES OF APPOINTMENT
Kenneth H. Olsen
Life Member
George W. Thorn
Life Member, Emeritus
Helen F. Whitaker
Life Member, Emeritus

ELECTIONS
Harl P. Aldrich
Member
Elisabeth M. Drake
Member
George M. Keller
Member
Barbara M. Johnston
Member

MEMBER EX OFFICIO
Angus N. MacDonald
President
Alumni Association

TERMS EXPIRED
William H. Mills
Member
Personnel Changes

Arno R. Minkkinen
Architecture

Francis Noblesse
Ocean Engineering

Michael G. O'Callaghan
Mechanical Engineering

Elisabeth Pate-Cornell
Civil Engineering

Melinda Rabb
Humanities

Robert Sturges
Humanities

Michael F. Van Breda
Sloan School of Management

Manuel Weiss
Athletic Department

John Wilkes
Humanities

Wilburn Williams
Humanities

Michael D. Zisman
Sloan School of Management

CHANGES OF APPOINTMENT

Behrouz Abedian
Visiting Assistant Professor in
Mechanical Engineering

Raymond M. Baker
Visiting Scientist in Biology and
Center for Cancer Research

Bernard F. Burke
William A. M. Burden Professor in
Astrophysics in Physics

Clark K. Colton
Bayer Professor of Chemical
Engineering in Chemical Engineering

Loren C. Cox
Director for Center for Energy
Policy Research and Lecturer in
Sloan School of Management and
Energy Laboratory

John M. Essigmann
Assistant Professor of Toxicology in
Nutrition and Food Science

Howard Green
Visiting Professor in Biology

Irene Greif
Principal Research Associate in
Laboratory for Computer Science

James R. Melcher
J. A. Stratton Professor of
Electrical Engineering in
Electrical Engineering and Computer
Science

Michael A. Moskowitz
Visiting Lecturer in Nutrition and
Food Science

Walter Olsen
Research Affiliate in Harvard/MIT
Division of Health Sciences and
Technology

Michael J. Piore
Mitsui Professor of Problems of
Contemporary Technology in Program
in Science, Technology, and Society

Peter A. Politzer
Principal Research Scientist in
Plasma Fusion Center

Robert O. Ritchie
Lecturer in Mechanical Engineering

J. Mark David Schuster
Lecturer in Urban Studies and
Planning

Mohammad Shamsuddin
Visiting Associate Professor in
Materials Science and Engineering

Abraham J. Siegel
Dean of the Sloan School of
Management

Henry I. Smith
Professor in Electrical
Engineering and Computer Science

John E. Thomas
Research Scientist in
Spectroscopy Laboratory

Anne Vernez-Moudon
Research Affiliate in Laboratory of
Architecture and Planning

NEW FACULTY APPOINTMENTS

Associate Professors:

Charles Alcock
Physics

Lennox L. Cowie
Physics

Gary Kavanagh
Ocean Engineering

Scott D. Tremaine
Physics

Assistant Professors:

Thereza Imanishi-Kari
Biology

Monty Krieger
Whitaker College and Biology

Charles E. Leiserson
Electrical Engineering and
Computer Science

Paola M. Rizzoli
Meteorology and Physical
Oceanography

S. Shankara Sastry
Electrical Engineering and
Computer Science
VISITING FACULTY

Visiting Professors

Norman Abramson
Electrical Engineering and Computer Science

Frank A. Bovey II
Chemical Engineering

Nils Christensen
Materials Science and Engineering

Richard C. Dorf
School of Engineering

John M. Hunt
Earth and Planetary Sciences

Hakuai Inoue
Chemical Engineering

Burton H. Klein
School of Engineering

Sydney G. Kustu
Biology

Theodore A. Loukakis
Ocean Engineering

Nathan Lyons
Architecture

Sheldon Weinbaum
Mechanical Engineering

David Wheeler
Humanities

Robert C. Wood
Political Science and Urban Studies and Planning

Visiting Associate Professors

Carmen Corneil
Architecture

Wayne D. Erickson
Chemical Engineering

Gunter Gottstein
Materials Science and Engineering

Peter Kugel
Division for Study and Research in Education

Masaki Sawamoto
Civil Engineering

AWARD

Alexander J. Rich
Professor in Biology; Killian Award Lecturer for the Academic Year 1980-81

ADMINISTRATION

DEATHS

Nicholas R. Ruggiero
Budget Officer
Fiscal Planning and Budget Office

RETIREMENTS

Harold L. Curtis, Jr.
Purchasing Agent
Purchasing and Stores

John T. Fitch
Director, Technical Education Group
Center for Advanced Engineering Studies

Edward L. McCormack
Auditor for the Institute
Audit Division

Millicent Taylor
Administrator for Personnel and Payroll
Information Processing Services, Operations

RESIGNATIONS

John M. Allen
Assistant Director
Office of Sponsored Programs

Gene F. Armstrong
Computer Services Coordinator
Information Processing Services, Operations

Richard S. Armstrong
Associate Director
Admissions Office

Beverly J. Chapman
Manager of External Relations
Sloan School of Management

Clare K. Chapman
Senior Research/Writer
Resource Development

Stephen Cooper
Records Management Officer
Libraries

Deborah Cozort
Librarian
Libraries

Roy A. Davey
Application Guidance Coordinator
Office of Facilities Management Systems

Edward M. Donovan, Jr.
Real Estate Property Manager
Treasurer's Office

Fred Finneran
Systems Analyst
Information Processing Services, Operations

John C. Gleason
Assistant Planning Officer
Planning Office

Charles J. Gisondi
Auditor
Audit Division

Donna L. Kennedy
Coordinator
Wellesley-MIT Exchange and IAP

Dmitry L. Khaskin
Applications Programmer
Information Processing Services, Operations

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Alumni Association

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Assistant Accounting Officer
Comptroller's Accounting Office

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Department of Earth and Planetary Sciences

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Treasurer's Office

Judith Lugus
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Office of Facilities Management Systems

James McTighe
Senior Staff Accountant
Student Accounts Office
Ronald Madany
Archival/Manuscript Specialist
Libraries

Rebecca Mans
Staff Manager
MIT Press

Richard P. Marvel
Benefits Officer
Benefits Office

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Sloan School of Management

Gloria Quintero
Systems Programmer
Information Processing Services, Operations

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Associate Designer
MIT Press

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Assistant Director
MIT Associates Program

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Personnel Officer
Personnel Office

Christopher Ryland
Computer Operations Manager
Department of Electrical Engineering and Computer Science

Nancy N. Sardella
Programmer Analyst
Information Processing Services, Operations

Carolyn A. Scheer
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Office of Personnel Information Services

Carole L. Taylor
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Campus Information Services

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Benefits Office

Joel Watson
Administrative Officer
Division of Comparative Medicine

Ellen Yen
Librarian
Libraries

Ramon Yi
Administrative Assistant for Accounting
Department of Nutrition and Food Science

Barbara V. Zeilenga
Administrative Assistant Manager
Resource Planning

APPOINTMENTS

Sarah Abrams
Staff Writer/Editor
Office of Communications
Resource Development

Rochelle G. Alexander
Quality Assurance Coordinator
Medical Department

Robert Boes
Applications Coordinator
Office of Facilities Management
Systems

Peter J. Boigvert
Systems Analyst
Information Processing Services, Operations

Robert Bolick
Acquisitions Editor
MIT Press

Peter Brown
Assistant Dean/Residence Programs
Office of the Dean for Student Affairs

George J. Carrette
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Department of Electrical Engineering and Computer Science

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Acting Associate Librarians

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Senior Staff Accountant
Treasurer's Office

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Center for Advanced Engineering Study

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Information Processing Services, Operations

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Planning Office

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MIT Press

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Physical Plant

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Physical Plant

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Development Office

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Libraries

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Bursar's Office

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Information Processing Services, Operations

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Boston Area Composers Project Libraries

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Libraries

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Industrial Liaison Office

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Medical Department

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Office of Sponsored Programs

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Information Processing Services, Operations

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Council for the Arts at MIT
Office of the President

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Conferences and Seminars
Center for Advanced Engineering Study

Benjamin F. Smith III
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Alumni Association

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Central Utilities Plant
Physical Plant

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Sloan School of Management

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Information Processing Services, Operations

Thomas L. Wilding
Assistant Director for Administrative and Personnel Services Libraries

Bruce Zabierek
Programming Analyst
Information Processing Services, Operations

CHANGES

Salim M. Alani
Auditor
Audit Division

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Staff Accountant
Comptroller's Accounting Office

Paul J. Arsenault
Staff Accountant
Comptroller's Accounting Office

Kathleen Arthur
Purchasing Agent
Purchasing and Stores

Vera J. Ballard
Personnel Officer
Personnel Office

Jill Bolin
Staff Accountant
Comptroller's Accounting Office

James F. Brady
Accounting Officer
Comptroller's Accounting Office

Andrew J. Brown
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Audit Division

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Audit Division

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MIT Historical Collections Libraries

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Comptroller's Accounting Office

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Information Processing Services, Operations

Ree Dawson
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Information Processing Services, Operations

Fay D. DeAvignon
Architect-Building Programming Design
Physical Plant

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Comptroller's Accounting Office

John Thomas Dreston
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Industrial Liaison Office

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Business Manager
Microreproduction Laboratory
Libraries
Gayle Fitzgerald
Assistant for Special Events
Campus Information Services

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Senior Staff Accountant
Lincoln Fiscal Office

Eleanor C. Forsberg
Senior Staff Accountant
Lincoln Fiscal Office

Jack H. Frailey
Director, Office of Student Financial Services
Vice President Financial Operations

Leonard V. Gallagher
Director
Student Financial Aid Office

Carol Gleason
Staff Accountant
Comptroller's Accounting Office

Michael Glover
Benefits Assistant
Benefits Office

Karen H. Goodall
Child Care Counselor
Child Care Office

Steven D. Goode
Assistant Contract Administrator
Office of Sponsored Programs

Suna Gulen
Applications Programmer
Information Processing Services, Operations

Jennifer D. Gwinn
Administrative Officer
Nuclear Engineering

James Hanlon
Supervisor, Administration
Information Processing Services, Operations

Diane V. Jaroch
Designer
MIT Press

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Industrial Liaison Office

Trond H. Kaalstad
Senior Administrative Officer
Department of Civil Engineering

David Kalendarian
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Information Processing Services, Operations

Bonny S. Kellermann
Director of Educational Council Admissions

Clyde Kelley
Manager Information Systems
Industrial Liaison Office

Carla W. Kirmani
Administrative Assistant
Department of Psychology

Heather D. Kraemer
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Office of Sponsored Programs

Justina M. Leler
Supervisor
Accounting and Business Service
Medical Department

E. Barbara Lewis
Executive Officer
MIT Sustaining Fellows Program
Resource Development

Patricia A. Lewis
Senior Staff Accountant
Department of Chemistry

Kathryn W. Lombardi
Executive Assistant to the President and Manager, Campus Information Services
Office of the President

Spencer Love
Systems Programmer
Information Processing Services, Operations

Laura Lupkiewicz
Senior Applications Programmer
Information Processing Services, Operations

Ann S. McCormick
Assistant Bursar
Bursar's Office

William H. MacLachlan
Safety Officer

Joseph Martori
Associate Secretary of the Alumni Association
Alumni Association

Howard F. Miller
Executive Assistant to the Vice President
Vice President, Operations

Thomas E. Mullen
Assistant Comptroller
Cost Development
Comptroller's Accounting Office

Susan K. Nutter
Assistant Director for Collection Management
Libraries

John F. O'Brien
Assistant Bursar
Bursar's Office

John D. O'Sullivan
Assistant Comptroller
Cost Development
Comptroller's Accounting Office

Joseph B. Paiva
Staff Accountant
Comptroller's Accounting Office

Claire L. Paulding
Data Base Manager
Office of Personnel Information Services

Ann Starr Perkins
Personnel Officer
Personnel Office

Deborah W. Pfeiffer
Staff Accountant
Comptroller's Accounting Office

Jane Hope Powers
Staff Accountant
Comptroller's Accounting Office

Elizabeth Reed
Assistant to the Director
Career Planning and Placement Office

Joan F. Rice
Assistant to the Director of Personnel
Personnel Office

John R. Rogers
Associate Bursar
Bursar's Office

Ruth Janet Romaine
Assistant to the Dean
School of Humanities and Social Science
President

Donna A. Schenkel
Assistant Design Manager
MIT Press

Sandra Sozanski
Symposium Coordinator
Industrial Liaison Office

Holly Sweet
Assistant Director
Experimental Study Group

Diane E. Tenen
Staff Accountant
Comptroller's Accounting Office

Mary Glenn Vincens
Staff Writer/Editor
Wellesley-MIT Exchange and IAP

Therese M. Viohl
Assistant Manager of Wage and Salary Administration
Personnel Office

Marina X. Vrouvlianis
Senior Applications Programmer
Information Processing Services, Operations

Jane Wells
Staff Associate
Analytical Studies and Planning Group

Lillian Whelpley
Administrative Assistant
Information Center

Kerry B. Wilson
Manager of Compensation and Employment
Personnel Office
In this report I will discuss one major external issue and a few important developments which affect the Institute as a whole.

The major external issue is the possible imposition of secrecy requirements onto university life. This affects the entire US academic community, but it is particularly pressing on an institution devoted strongly to science and technology. The restrictions with which we have to deal are of two types: military classification and export controls.

Faculty members in the Departments of Mathematics and Electrical Engineering and Computer Science have been doing frontier work in complexity theory, a branch of higher arithmetic which has direct applications to cryptography. Evidently, cryptography can be of extreme importance to military security, and certain research may properly require classification. However, cryptographic research is also of crucial importance to the civilian economy, which is increasingly computerized, so that protection of privacy and protection against computer crime are needed. We in the academic community must first make sure that the line between results that require classification and results whose dissemination is vital to the civilian sector is sensibly drawn. We must then make sure that, in spite of the vagueness of that boundary, we are able to conduct our unclassified research in a manner which is consistent with our tradition of openness and free exchange of information.

Export controls pose a somewhat different, and in some ways a more difficult, problem. We are dealing here mainly with so-called dual-use technology. Dual-use technology is primarily for civilian use, but has possible military applications, and might therefore be exploited militarily by a potential adversary. The difficulty here is two-fold. First, since almost any item which is of civilian use can also be used by the military, how should the controlled list be drawn up? The answer is by regulation. The list is drawn up by the Defense Department and administered by the Department of Commerce. Second, what constitutes "export"? Here the situation is vague. Publication is not considered export, but communication with a foreign national, even a friendly one, is. This poses serious difficulties for the MIT community, in which foreign students and staff members play an important role, and in which major items of our research and educational programs are either on the export control list, or obvious candidates to be put on the list. These items include cryptography, Very Large Scale Integration (VLSI) and sub-micron technology, robotics, computer-aided design, and more. So far, these regulations have been administered on the whole in a way which is sensitive to the special problems of the universities. It is essential that this continue to be the case.

The set of problems under discussion was forcefully addressed in a letter to the secretaries of State, Commerce, and Defense from the presidents of Cal Tech, Stanford, the University of California, Cornell, and MIT. The letter was stimulated by a number of events, including a memorandum by the director of the Very High Speed Integrated Circuit (VHSIC) program. The letter said, in part:

Restricting the free flow of information among scientists and engineers would alter fundamentally the system that produced the scientific and technological lead that the government is now trying to protect and leave us with nothing to protect in the very near future. The way to protect that lead is to make sure that the country's best talent is encouraged to work in the relevant areas, not to try to build a wall around past discoveries.

It should be recognized that the only realistic way to "contain" VHSIC research is to classify the whole program. In our view this would be a self-defeating effort: the science underlying high technologies cannot be put back into the bottle. Furthermore,
most universities have concluded that performance of classified research is incompatible with their essential purposes. University scientists would prefer, for the most part, to change their field of interest rather than have their research and teaching so constrained. Forcing high technology research out of universities would decrease our nation's competitive position, since the research would have to be carried out more slowly and less effectively in a classified atmosphere. Moreover, we would foreclose future research directions that would otherwise be discovered by having a continuous flow of new graduates from the university programs which have been flourishing up to this point. Elimination of such teaching and research from academic laboratories would endanger the future of graduate programs in engineering, computer science, and related fields, and would result in a tremendous loss of potential high technology otherwise available to American industry. The new restrictions represent the worst possible direction: they fail to protect the status quo and virtually guarantee that there will be no future.

Moreover, application of export restrictions to universities would pose significant practical difficulties. It would be virtually impossible for most universities to administer such restrictions given the necessarily decentralized and fluid nature of most campuses. Because it is so inconsistent with their character, universities are neither structured nor staffed to police the flow of legitimate visitors to a given laboratory or the dissemination of information by their faculty at international conferences, or, indeed, even in a campus classroom where foreign students happen to be present.

It is clear that government agencies have an obligation to protect the military and economic security of the United States. This obligation can be carried out in part by restricting the flow of information and technology to potential adversaries, but as importantly by encouraging research and development within the country. It is not universally recognized that the first of these methods inevitably inhibits the second. I take it as axiomatic that scientific and technological innovation and development take place most effectively in an atmosphere of open discussion. Restrictions on the exchange of ideas necessarily result in a weakening of the creative process, so that mechanical imposition of restrictions can in fact lessen our military and, even more, our economic security. Particularly in the university, where education and research have been so inextricably and fruitfully combined, the imposition of restrictions goes against tradition and against wise educational policy. A hasty application of secrecy restrictions to universities would result in forcing them to abandon research areas to which they have made substantial contributions in the past, and surely would make more in the future.

Here at MIT there is a faculty committee, chaired by Professor Michael L. Dertouzos, director of the Laboratory for Computer Science (LCS), which is looking at both questions (classification and export) and attempting to formulate a satisfactory MIT policy. At the same time, MIT faculty members and administrators have been meeting with government agency officials, trying to work out solutions that will be responsive simultaneously to the needs of the government and those of the university community.

During the past year two developments related to the life sciences have received considerable attention from this office.

First, Edwin C. Whitehead has offered to endow an independent institute for biomedical research near MIT which would, for educational purposes, have a close partnership with us. Many discussions as to the nature of the partnership have taken place between the different interested groups: the Whitehead board, the MIT administration, the Department of Biology faculty, the MIT Corporation and its Executive Committee, and various groups of MIT faculty members. The issues are not yet completely resolved but the discussions have reached a point where I feel it appropriate to include a short account in this space. As of this writing no final agreement on all issues has been reached. I hope that a final decision will be made before 1982.

Very briefly, the Whitehead Institute (WI) is planned to be an independently endowed pure research institute. It will have its own self-perpetuating board of 14 members including the director, three MIT nominees and, on the first board, three jointly agreed upon members. The first director will be Dr. David Baltimore, American Cancer Society Professor in the Department of Biology. WI will have, when fully endowed, about 20 faculty-level appointments. It is anticipated that most of these will receive simultaneous appointments as MIT professors, although their complete financial support will come from the Whitehead Institute so that MIT will have no financial
liability. These appointees will have the usual professional obligations, including formal teaching, graduate student supervision, and service on MIT committees. They will be appointed following the usual MIT procedures.

This planned association is a novel one. I believe it carries with it real opportunities for the combined MIT-Whitehead life sciences community to move into new and exciting areas in this important and expanding field.

Second, progress toward the development of the Whitaker College of Health Sciences, Technology, and Management as a focus for certain health-related activities also continues to be quite satisfactory. In particular, gifts of $2.5 million and $1.0 million have been received from the Kaiser Foundation and the Pew Memorial Trust, respectively. The former will make possible a new program in health policy and management, and the latter will assist in the procurement of important equipment for the new laboratories. A committee chaired by Associate Provost Kenneth A. Smith has been examining the specific programmatic thrusts of the College with the object of determining the relative emphasis which might most appropriately be accorded to each. The new building is expected to be ready for occupancy by the end of this calendar year and the role of the College will then become even more important.

* * *

During the past year a report was received from a joint MIT/Woods Hole Oceanographic Institution (MIT/WHOI) committee which had been appointed by the provosts of these two institutions to review the status of the Joint Degree Program in Oceanography. That report concluded "that the Joint Program is an asset to both MIT and WHOI and should be continued, but that significant improvements are required." Most of the areas identified as requiring improvements were related in one way or another to differences in style, philosophy, and mission of the two institutions and failure to accommodate adequately to these differences. The principal recommendation of the review was creation of "a substantially different organization for the Joint Program."

Steps to implement that new organization were begun. Dr. John G. Sclater, Professor of Earth and Planetary Sciences at MIT, was appointed to serve as the Provost's designate to a new Joint Program Committee which will be responsible for establishing general policies and procedures of the Joint Program. He will join Dr. Charles D. Hollister, Dean of Graduate Studies and Senior Scientist at WHOI, in providing overall administrative support and direction of the Joint Program.

FRANCIS E. LOW

Artificial Intelligence Laboratory

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

Professor Patrick H. Winston, director of the Artificial Intelligence Laboratory, heads the research effort in learning and reasoning by analogy. Professor Berthold K. P. Horn and Professor Shimon Ullman direct work in computer vision. Dr. J. Michael Brady, Dr. John M. Hollerbach, and Professor Tomas Lozano-Perez lead research on computer-controlled, multiple-joint manipulators and other aspects of robotics. Professor Randall Davis and Professor Carl E. Hewitt work with distributed problem solving and parallel computation. Professor Marvin Minsky develops general theories of artificial and natural intelligence. Professor Gerald J. Sussman, Dr. Howard E. Shrobe, and Thomas F. Knight work on the problems of integrated circuit design. Dr. Charles Rich and Dr. Richard C. Waters explore the creation of intelligent programming environments. Richard D. Greenblatt does research on memory and heuristic control. Professor Seymour Papert leads efforts concerned with education through the use of computers.
The Laboratory's 80 members include 10 faculty, 35 research and support staff, and 30 graduate students involved in research activities funded by the Defense Advanced Research Projects Agency (DARPA), the Office of Naval Research, the Air Force Office of Sponsored Research, the National Science Foundation, the Olivetti Corporation, the Xerox Corporation, the Jet Propulsion Laboratory, and IBM.

**Image Understanding**

Professor Horn's group studies the problems associated with the relationship between the shapes of visible surfaces and their gray-level shading. In particular, Professor Horn formulated the image-irradiance equation, which relates surface orientation to brightness values, and he developed the reflectance map, which graphically displays the constraint implied by the image-irradiance equation.

One application of the image-irradiance equation and the reflectance-map representation is centered on the development of albedo maps, in which ground slope and sun position are factored out so that intensity is solely a function of ground cover. A crucial step in this application, the generation of high-quality synthetic images, is difficult because of atmospheric scattering. Professor Horn and Robert J. Sjoberg have demonstrated that although understanding the effects of the atmosphere is a difficult task, the adoption of even simple models can provide substantial improvement over results obtained with no model. In particular, they have showed how the abundance of shadows cast in mountainous regions can aid in the determination of path radiance. Professor Horn and Mr. Sjoberg are extending the models in order to extract calibration data from multichannel images and from multiple images taken a few days apart.

In general, the image-irradiance equation has an infinite number of solutions, each corresponding to a surface. Thus shading alone is not sufficient to determine a surface uniquely. Working with Professor Horn, Dr. Anni R. Bruss has examined the use of supporting information from silhouettes, edges, and rotational symmetry, showing how to arrive at unique solutions in some cases. In particular, she has showed when the images captured by scanning electron microscopes determine surface shape uniquely.

Professor Horn and Brian G. Schunk continue to investigate the use of the image-irradiance equation in determining the instantaneous positional velocity field which is generated on the image plane by moving in a textured environment. One important application is in navigation, where it is desirable to determine camera motion from noisy image sequences. Professor Horn and Dr. Bruss have devised a least-squares approximation technique to handle the special case of pure rotation. An implementation is in progress.

Professor Horn and Drs. Brady and W. Eric L. Grimson used the calculus of variations to investigate the idea that the human visual system constructs the most conservative curve or surface that is consistent with the data provided in an image. For planar curves, Professor Horn derived an analytical expression for the curve that minimizes the integral square curvature. Drs. Brady and Grimson noted that small angle approximations reduce Professor Horn's curve to a cubic.

Dr. Grimson established conditions under which a most conservative surface is guaranteed to exist. He showed that the quadratic variation satisfies the conditions for existence. Professor Horn and Dr. Brady showed that any quadratic form in the second derivatives of a surface also satisfy the conditions. More importantly, they showed the quadratic forms that are rotationally invariant from a vector space which has the square Laplacian and quadratic variation as a basis. The quadratic variation is preferred because it has more tightly constraining natural boundary conditions.

**Natural Vision**

A model of two important aspects of retinal function has been proposed by Professor Shimon Ullman and Dr. Jacob Richter. Their computational theory addresses the role of the retinal ganglion X- and Y-cells. The X-cells implement in human vision what has been modeled mathematically as the convolution of the Laplacian of a Gaussian filtered image. These cells provide the visual cortex with information about the location of rapid intensity changes, from which intensity features such as edges, bars, and blobs can be detected. The X-cells constitute the basic input for much of
later visual processing such as stereo, texture, and contours. The Y-cells, which appear to be
the primary input for perceiving visual motion, are modeled as the time derivative of the Laplacian
of the Gaussian filtered image. Professor Ullman and Dr. Richter show how these two mathematical
functions can be implemented by the neural architecture of the retina, particularly by synaptic
interactions. Dr. Richter has continued this research into the next stage of visual processing,
wherein X-cell input to the visual cortex is used to detect the location and orientation of inten-
sity edges. That current line of work dovetails with a theory of edge detection developed by the
late Professor David C. Marr in collaboration with Ellen C. Hildreth.

The processing of retinal intensity information is therefore becoming better understood, and
allows the generation of specific computational models for various later processes. In particular,
a theory of human stereo has been developed by Professor Tomaso Poggio and the late Professor
Marr. A computer implementation by Dr. Grimson has allowed a quantitative comparison of this
model with the known psychophysics of human stereopsis. During the past year, Dr. Grimson
also explored several computational issues regarding the process of deriving a representation of
a smooth surface given the incomplete sort of information that stereopsis naturally provides.

Other computational problems that are under investigation regard the representation of continuous
curves or contours from local edge or line information by Dr. Kent A. Stevens, the detection of
texture discontinuities by Michael D. Riley, and the modeling of directional selectivity to visual
motion by Ms. Hildreth.

Dr. H. Keith Nishihara and Noble G. Larson have developed hardware for processing images with
Gaussian filters, thereby working toward a real-time stereopsis machine.

Dr. Brady used the Marr-Hildreth theory of edge detection to create a theory of early visual
processing in reading that accommodates known psychophysical data about eye movements and the
reading of transformed scripts. Dr. Brady plans to extend it to provide a computational explana-
tion for the faster, more reliable perception of words and orthographically plausible pseudowords.

Robotics

Ordinary human abilities, such as the planning of motions in a world of obstacles to reach some
goal without collision, are difficult to automate. Professor Lozano-Perez developed a system of
wide generality which constructs a hierarchical tessellation of space and efficiently computes grasp-
ing positions and paths for a polyhedral object in terms of the space of allowable configurations.
Professor Lozano-Perez is now designing a high-level manipulator language in which his spatial
reasoning system will be embedded.

In addition to an ability to reason about space, a high-level manipulator language must have an
ability to reason about the interaction of manipulators and objects. Matthew T. Mason has un-
covered some simple rules governing the collisions which occur when a manipulator grasps or
pushes objects.

Working together, Professor Lozano-Perez and Mr. Mason implemented new software that enables
a minicomputer to perform time-critical functions while a LISP-oriented computer does task plan-
ning and supervision. This software drives a manipulator designed by John A. Purbrick, which
uses an innovative stepping-motor control system developed by Messrs. Larson, Mason, and
Purbrick.

William M. Silver has worked on another aspect of manipulator control, extending some previous
results on manipulator dynamics worked out by Dr. Hollerbach. Dr. Hollerbach had used a
Lagrangian approach to obtain an especially simple form of the equations of motion. Mr. Silver
demonstrated that Dr. Hollerbach's Lagrangian approach is equivalent to results obtained using
a Newton-Euler approach.

A three degree-of-freedom tendon-driven shoulder, designed by Dr. Hollerbach, and two high-
resolution touch sensors, one designed by Mr. Purbrick and one designed by William D. Hills,
continued to receive attention, with emphasis on experiment.

Dr. Hollerbach and Tamar Flash of the Psychology Department studied the interaction forces
during human-reach movements. Kinematic information is collected from subject-arm movements
and fed into a simulator to compute the various contributions to the torques. Surprisingly, their initial experimental results indicate that the relative magnitude of the velocity terms with respect to the reaction terms is independent of the speed of movement. They find evidence that humans choose trajectory-formation strategies that simplify the dynamics computation.

During the past year, a great deal of effort went into preparation for expansion of the Laboratory's work in robotics. This preparation included the development of ties with other laboratories and centers and with the Department of Electrical Engineering and Computer Science, the Department of Mechanical Engineering, and the Department of Psychology.

Dr. Brady and Professor Richard Paul of Purdue University founded a new journal titled Robotics Research. MIT Press is the publisher.

Learning from Experience and Natural Language Understanding

Professor Winston's theory of reasoning by analogy has led to a system with the following parts: a hypothesizer that searches memory for precedents likely to be useful in analyzing a new problem; a matcher that finds the most useful correspondence between a retrieved precedent and the given problem using the causal framework found in the precedent; and a reasoning system that reaches conclusions about the problem using the precedent. During the past year, Professor Winston has developed a technique for generating abstract rules as a by-product of the problem-solving effort. These abstract rules are similar to those that appear in systems developed elsewhere for medical diagnosis and oil well log analysis. Professor Winston expects his work to lead to learning systems that acquire expert knowledge from experience, reducing the need for expensive and unreliable acquisition from human experts.

Boris Katz produced an English input module for Professor Winston's analogy system using the same approach he developed for generating English text from semantic representations. His generation system subdivides into three relatively independent steps: the first generates a set of kernel sentences from the semantic representation; the second uses syntactic and thematic considerations to determine the set of transformations to perform on each kernel; the third executes the specified transformations, combines the altered kernels into a sentence, performs a pronominalization process, and produces the appropriate English word string.

Expert Problem Solving in Programming

Drs. Rich and Waters analyze the logical structure of programs in order to create intelligent programming environments. They have devised a representation called a plan, a language-independent representation for a program that stands above the syntactic details of the programming language and represents control flow and data directly. The central idea is that typical programs are built up in a small number of stereotyped ways by what are called plan-building methods.

The power of the program-analysis system is demonstrated by the fact that it can produce plans for COBOL programs as well as for LISP and FORTRAN programs. Dr. Waters also constructed a coding module which produces LISP code from a plan. It has been tested on several dozen plans, including some which were produced by automatically analyzing COBOL and FORTRAN programs. The LISP programs produced range from several lines to several pages long.

VLSI

Professor Sussman and his associates work on design tools for Very Large Scale Integration (VLSI) and on innovative ways to exploit VLSI hardware. During the past year, Professor Sussman and John D. Batali continued to develop the Design Procedure Language (DPL) for describing a hierarchical abstract wiring diagram for a device. Messrs. Batali, Edmund Goodhue, and Christopher Hanson have developed software for translating control-unit function into a form accepted by the DPL system.

Dr. Shrobe continued to develop the Daedalus system, a graphics interface to the DPL system. One new feature allows fracture lines to be placed, describing places where a circuit may be
stretched. Another allows the conditional interpretation of standard cell parts, allowing proper
display even though the use and the precise form of a cell vary.

Mr. Knight has designed and fabricated a prototype silicon image sensor which includes image
processing implemented through a hybrid analog/digital approach. The operation of the chip
relies on interconnections that make it behave like a finite-element approximation to a distributed
transmission line governed by the diffusion equation. The resulting computations are Gaussian
convolutions which can be differenced to form approximations to the operations that are required
in early vision processing.

Mr. Hillis is currently leading an investigation into the possibility of building a concurrent com-
mputing machine for searching data bases with 10,000 times more facts than those in today's expert
systems. The proposed machine, called the connection machine, is a locally connected array of
cells. In contrast to the memory cells in ordinary serial machines, each cell in the connection
machine is to have not only the hardware necessary to hold an item of data but also the hardware
necessary to manipulate it.

Distributed Problem Solving and Computing

Professor Davis studies some of the fundamental issues that must be faced in distributed planning
and problem solving. Motivations for distributed planning and problem solving include both
economic forces (which suggest connecting many small computers together to work on a common
goal), as well as arguments based on reliability and graceful degradation in performance if one
of many machines stops functioning. Professor Davis has begun studying planning strategies
that make sense in a world populated by multiple agents, none of which has complete knowledge,
and is exploring techniques for producing plans that produce robust, cooperative, and cautious
behavior.

Professor Hewitt investigates the issues surrounding the creation of multiprocessor systems.
A central problem in any multiprocessor system concerns the topology of interconnections between
the individual processors, and this in turn determines the lengths of the wires between processors.
Some researchers have suggested placing processors at the vertices of an n-dimensional cube so
that the maximum number of hops between processors is the logarithm of the number of processors.
This topology has the disadvantage that almost all the wires are extremely long, which is dis-
advantageous in VLSI systems. In order to deal with this problem Professor Hewitt, in collaboration
with Professors Robert H. Halstead, Jr., and Richard E. Zippel, developed the idea of using a
folded n-dimensional hypertorus, which can be visualized as wrapping opposite sides of the n-cube
to make them adjacent. Jeffrey I. Schiller has constructed a test-bed implementation based on
three of the Laboratory's LISP Machines, and a simulator for a 64-node system using the folded
Cartesian hypertorus geometry of interconnections. This has enabled pilot studies of the impor-
tant idea of work sharing and dynamic load balancing to be started. Recently Phyllis A. Koton
constructed a communications VLSI chip called PORTAL-0 to facilitate further experimentation
with the Apiary.

Professor Hewitt studies intelligent office-support systems based on multiprocessor systems.
One key part of his system is the OMEGA knowledge-representation language. Dr. Giuseppe
Attardi and Marin Simi defined OMEGA's semantics axiomatically. Gerald Barber constructed a
highly interactive implementation of OMEGA using the ETHER system of multiple interacting
processes constructed by William A. Kornfeld. Another key part of Professor Hewitt's office
system is provided by ACT-1, a programming language that is based on actors. Dr. William
Clinger recently defined ACT-1 formally.

The Computing Environment

Several years ago Mr. Greenblatt conceived of the LISP Machine, a computer that gives its users
more symbol manipulation and list-processing power than had ever been available before. During
the past year the number of these machines in the Laboratory increased to 14, enabling research
that otherwise could not be done. All of the LISP Machines, five PDP 10s, two ETHERNET gate-
ways, and miscellaneous computers and terminal concentrators are linked together with an eight-
megabit packet-oriented cable system known as the CHAOSNET.
Basic Theory

Professor Minsky continues work on his *society of minds* theory, in which 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 restricted in amount and in complexity.

Professor Minsky's approach may illuminate the psychological theories of Piaget and Freud, as well as give coherence to artificial intelligence theories that do not consider the kinds of problems inherent in the representation of a personality. The limitations of inter-agent communication make it necessary for the mind to develop hierarchies of control structures that may be similar to developmental stages. The censors and critics of the hierarchy settle conflicts by referring to early developed self-images.

Professor Minsky's work has led to new ways to organize very large knowledge-based computer programs, such as the building of large, active computer memories, useful for dealing with the representation of common-sense knowledge.

Education

The LOGO Group, under the direction of Professor Papert, applies theoretical and technological developments in computer science to education. All of the group's activities are done in collaboration with the Division for Study and Research in Education.

Dr. Sylvia Weir, Professor Papert, Jose Valente, and Gary Drescher use computer-based techniques to address the diagnostic and educational needs of children with physical, learning, and emotional handicaps. Work with the learning disabled involves the isolation of a spatially gifted subcategory of the population, using the computer as a source of formal spatial reasoning. This work links recent brain-behavior correlation research with computer-based spatial learning environments that have been generated by the application of artificial intelligence to education.

PATRICK H. WINSTON

Cell Culture Center

The Cell Culture Center at MIT has been established and funded by the Human Cell Biology Program of the National Science Foundation (NSF). 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 MIT, 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 is working directly with individual scientists on basic research problems and, in addition, is conducting an active program in the development of new techniques for large-scale cell and virus production.

Production

During the period July 1, 1980, to June 30, 1981, the Cell Culture Center provided cells and/or virus materials to 38 research groups throughout the United States. Roller bottle production decreased in comparison to the previous year (75 percent vs. 104 percent capacity). However, this was accompanied by a significant increase in the production of suspension culture cells (79 percent vs. 50 percent of capacity). Most projects involved the production of cells for uses...
other than virus propagation and this was reflected in a decrease in the number of virus
purification runs (25 percent vs. 72 percent of capacity). Overall, production at the Center
continued at a high rate. Examples of projects completed during the past year include: 2,347
roller bottles of SV-80 cells for the University of Illinois at Urbana; 410 roller bottles of 2°CEF
for Sindbis for MIT; 1,730 roller bottles of CCL-47 cells for Sidney Farber Cancer Institute,
Boston; 1,483 roller bottles of FS-4 cells for interferon mRNA production for Johns Hopkins
University, Baltimore; 674 liters of HeLa S-3 cells for MIT; 882 liters of JY cells for Harvard
University, Cambridge; and 300 roller bottles of SK-MEL-28 cells for Sloan Kettering Cancer
Center, New York.

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

In addition to the NSF grant for support of large-scale cell and virus production, research and
development efforts at the Center have been supported by other grants and contracts.

Process Development and Delivery of Human Fibroblast Interferon. Considerable progress was
made on this project which was completed on June 30, 1981. Objectives which were achieved
during the past year on this project included:

1) Continued optimization of conditions for production of human fibroblast interferon with
microcarrier-grown cells.

2) A study of the various factors, e.g., oxygen consumption and shear forces, affecting
scale up of FS-4 cells.

3) The development of procedures which reduce non-specific adsorption of human fibroblast
interferon.

4) An examination of conditions controlling the production of leukocyte interferon by fibro-
blast cells.

Microcarriers for Mammalian Cell Propagation and Interferon Production. This project, which was
completed on January 30, 1981, involved efforts in small-scale microcarrier culture to optimize
conditions for the production of human fibroblast interferon. As a result of this study, yields
in excess of 50,000 units of interferon per ml can routinely be obtained with microcarrier-grown
cells.

Human Cell Culture Production of Opsonic Protein (Fibronectin). The overall goal of this project,
which is ongoing, has been to utilize microcarrier-grown human cell cultures for the production of
fibronectin. Work to date on this project has resulted in the purification of, and the development
do, a radioimmunoassay for fibronectin.

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 stu-
dents with excellent preparation for vocations that require a broad knowledge of the techniques
of cell culture and animal virology. During the past academic year, four students successfully
completed the program.
Cell Sorter Laboratory

During the past year, a Cell Sorter Laboratory was established as a functioning unit of the Cell Culture Center. This process involved the preparation of laboratory space with specialized capabilities, the installation of the instrument and subsequent trouble shooting as required during the normal to lengthy breakin time. The instrumentation that we have installed is the System 60 by Ortho Diagnostic Systems, which consists of a System 50 Cytofluorograph Cell Sorter with an argon laser, plus an ICP22 (an analysis-only) instrument, originally marketed as Phywe, with a mercury arc lamp as the excitation source. We now operate a lab which is offering many standard options for cell analysis and sorting, as well as beginning to develop new techniques as a resource.

Some examples are:

1. Immunofluorescence assays using an indirect "sandwich" technique with conjugated fluorescein.
2. DNA analysis using a variety of stains such as Propidium Iodide, DAPI, ethidium bromide, mithramycin.
3. Membrane perrenual, using several of the class of cyanine dyes.
4. Sorting on the basis of light scatter parameters as a measure of cellular development.
5. Analysis of marine phytoplankton with adaptation of animal cell staining techniques to diatoms.

Three workshops on the theory of operation of flow cytometry have been given in order to educate new users and generate interest in the potential for information collection.

The expectation for the next six months is that the use of the cell sorter will increase to capacity with a collection of regular system users as well as a fluctuating population of short-term projects. It is anticipated that a computer data handling system and real-time control will be added within the next two months. This will add greatly to our flexibility and potential use to the research community.

PHILLIPS WESLEY ROBBINS

Center for Advanced Visual Studies

The Center for Advanced Visual Studies (CAVS) was formed in 1967 by Gyorgy Kepes. Dedicated in 1968, it has been directed by Otto Piene since 1974. During its lifespan of 13 years it has hosted 80 artists and scientists, including a current population of 25 Fellows. Devoted to art, science, and technology, work at CAVS is most active in three areas -- individual art and research work, group work among artists, scientists and engineers, and education. Theses in the S.M.Vis.S. program presented such subjects as, "Sculpture as Process" (Bernd Kracke), and "Environmental Video: Personal Forms for Television's Public Context" (Vin Grabill). An outstanding subject among CAVS educational offerings has been "The Artists Speak -- Work of the Fellows of the CAVS."

Group efforts of Fellows and graduate students manifested themselves in the presentation which Otto Piene gave in various media at the Ars Electronica Festival/Bruckner Fest in Linz, Austria, in September 1980; in the series of "Centervideo" programs in several places in Europe; and in the preparations for four Sky Art Conferences, 1981-84, to begin at MIT in September 1981.

"Centervideo" is an exhibition/program of artistic video and film work, 1968-81, by approximately 25 CAVS artists. A one-week presentation originated at The American Center in Paris in February 1981, and subsequently toured the Koelnischer Kunstverein in Cologne and the Kunsthaus Zuerich. It will continue its course throughout 1981. Public reaction was very favorable to this program, which was sponsored predominantly by MIT and by the US government through foreign embassies and the International Communication Agency.
Groups of individual works by CAVS artists (e.g., Joan Brigham, Harriet Casdin-Silver, Paul Earls, Wendelin Glatzel/Peter Codella, Chris Janney, and Mark Mendel) were presented in exhibitions, events, and panels of the "Collaborations One" conference, April 1-8, 1981, at Connecticut College in New London, Connecticut.

The following is a brief sampling of individual work by CAVS Fellows throughout the year: Joan Brigham, "Steamers" exhibition and a collaboration with artist-Fellow Chris Janney and the poet Emmett Williams, for "Steam Shuffle" at the Cambridge River Festival; Harriet Casdin-Silver, fellowship by, and consultancy for, the Rockefeller Foundation on the future of holography. Her work was televised for a NOVA program on WGBH, Boston; Wendelin Glatzel, showing of his video piece, "Centralperspective Breakdownlane," at the Museum of Modern Art, New York City; Paul Earls, with Otto Piene, "Laser Circus" for First Night, Boston, Massachusetts, and laser music for Portland Art Museum, Portland, Oregon; Christopher Janney, "Sonic Pass" and "Soundstair Installation" at Mississippi Museum of Art, Jackson, Mississippi, and soundscapes and environments for dance for Boston choreographer, Martha Gray; Mark Mendel, one-man show of environmental poetry at Franklin Furnace, New York City; Carl Nesjar, completion of his environment of fountains and liquid prisms for city hall park in Moss, Norway, and participation with Otto Piene and others in "Plast i Kunst" at the Kunstnernes Hus, Oslo; Otto Piene, one-man exhibitions at the State University of New York at Stony Brook Fine Arts Gallery at the Galerie Schoeller, Düsseldorf, and at the Galerie Loehrl, Moenchengladbach, Germany. He created the sky event "Blue Star Linz" for an outdoor audience of 60,000 at the Bruckner Fest Ars Electronica in Linz, Austria, 1980, and he participated in "Westkunst," a comprehensive survey of 20th Century art, in Cologne, 1981; Aldo Tambellini authored and/or participated in various telecommunication events, notably "Interfaces," between CAVS and the American Center in Paris, the collaboration with numerous other CAVS artists for the opening of "Centervideo" in Paris (among collaborators: Ken Kantor, Bernd Kracke). Right after finishing his S.M.Vis.S. thesis, Todd Siler had a one-man exhibition at both Ron Feldman galleries in New York City.

Among grants given to CAVS and Fellows were a National Endowment for the Arts preparation grant for the Sky Art Conference; various forms of support from the Massachusetts Council for the Arts and Humanities and Artists Foundation; numerous grants from the MIT Council for the Arts; and private foundation grants to CAVS, such as those from the Jewish Community Federation in Cleveland and the Joel Dean Foundation. Important support of artwork was given by MIT to CAVS media artists through their use of the Educational Video Resources' studios and resources.

CAVS publications reflected writing and artwork in specific areas: "Centerbeam," edited by Otto Piene and Elizabeth Goldring and published by MIT Press, sums up the CAVS "Centerbeam" environmental kinetic art projects of recent years; "Centervideo" presents data and comments on CAVS media work since the Center's inception in 1968; Otto Piene, Paul Earls, and assistants illustrated a Smithsonian Magazine article on nuclear fission and fusion, by Phillip Boffey, with photographed laser image projections. Elizabeth Goldring wrote "Sky Art -- Art That Flies" for Braniff's Flying Colors. Major articles on CAVS art and artists appeared in such diverse publications as OMNI, Machine Design, United Mainliner, and Lightworks.

OTTO PIENE

Center for Cancer Research

The year 1980-81 was one of quiet transition at the Center for Cancer Research. The installation of Professor Susumu Tonegawa's research group on genetic immunology in newly renovated laboratories has begun, and Professor Thereza Imanishi-Kari has initiated her program in cellular immunology. With the addition of these two distinguished scientists to Professors Herman N. Eisen and Michael J. Bevan, MIT can now boast of having one of the outstanding groups of cancer-oriented immunologists in the world.

Professor David E. Housman, who has been in the Center since 1975, has been granted tenure. Professor Housman has recently developed a unique method to isolate human DNA from hybrid cells containing a mixture of human and rodent chromosomes, a technique that promises to be extremely valuable in the study and possibly the correction of human genetic defects.
A new teaching laboratory located in the Seeley G. Mudd Building, the installation of which is still incomplete, has been accomplished through use of MIT funds, and has been used to teach a project laboratory course on cancer cell biochemistry under the direction of Professor Phillips W. Robbins.

Professor Tonegawa, who is joining the Center faculty on July 1, 1981, received the Genetics Grand Prize, Japanese Genetics Society, in April 1981.

Faculty-level visitors to the Center for Cancer Research during the academic year 1980–81 have been: Professor Samuel Latt of Harvard Medical School, and Professor James Champoux, from the University of Washington in Seattle.

SALVADOR EDWARD LURIA

Center for Cognitive Science

INTRODUCTION

The pattern of research and training in cognitive science at MIT has focused on the development of a representational theory of mind called the Modularity Hypothesis. The Modularity Hypothesis holds that cognitive capacities constitute autonomous mental faculties, each with a distinctive representational type and computational character. The underlying goal of research and training conducted in the Center for Cognitive Science is to discover the principles according to which such cognitive faculties are organized. This work takes place at three separate levels of inquiry. The first concerns the formal structure of particular cognitive types; the second, the investigation of the specific performance algorithms by which such capacities are put into action; and the third, the embodiment of cognitive capacities and mental processes in neurological mechanisms. The motivation for this research may, of course, be theoretical, empirical, or applied.

What is perhaps unique to MIT is that integrated research is going forward on three distinct cognitive faculties: language, vision, and conceptual reasoning. Among the projects underway are several being carried out by Professors Jonathan Allen, Joan W. Bresnan, Noam A. Chomsky, Jerry A. Fodor, Merrill F. Garrett, Morris Halle, Samuel J. Keyser, and Dr. Kent A. Stevens on the relationship between linguistic theory, psycholinguistics, and the biological mechanisms of language. Similarly, the formalization of functions accomplished by early visual processing, the development of computational algorithms for processing visual arrays, and the study of the neural mechanisms of vision are the focus of work by Dr. J. Michael Brady, Professors Richard M. Held and Daniel N. Osherson, and Dr. Shimon Ullman. And finally, strong claims regarding the biological endowment of human cognition, its maturation, development, and use are the subject of empirical and theoretical studies by Professors Ned Block, Sylvain Bromberger, Susan Carey, Fodor, Osherson, and Mary C. Potter.

The Center itself provides practical and intellectual support for long-term research and training goals as referred to above. Current efforts are directed toward completing the curriculum developments recently initiated, and toward fostering the novel programs of interdisciplinary collaboration which have begun in the Center. A major research facility for experimental cognitive science is being installed to support the research and training programs which these efforts have engendered, and computational resources for research in cognitive modeling, as well as support for all phases of research activity, have been implemented. Programs of pre- and postdoctoral training are continuing, as are the distribution of a series of "Occasional Papers," a program of topical workshops in cognitive science, and a series of supplementary colloquia presented by outside speakers. The postdoctoral fellows in cognitive science conduct a joint seminar on mental representation.

Formal collaborative arrangements have been reached between the Center and the Scuola Normale of the University of Pisa, the Max Planck Institute for Psycholinguistic Research (Nijmegen), and the Centre National des Recherches Scientifiques (Paris). In addition, a number of collaborative projects have arisen between members of the Center and colleagues at various institutions in the Boston area.
The Center's activities are supported by grants from government agencies, private foundations, and industry, and by continuing contributions by the Institute itself. Total funds administered by the Center for fiscal year 1980-81 were approximately $1.0 million. This figure does not include various individual research grants involving members of the Center but located administratively in the participating departments. Competition for these funds is sure to be keener in the immediate future. However, in view of the commitment of the Institute and the past experience of the members of the Center in securing funds, it is expected that support for the Center's activities can be maintained.

During the three years which have passed since the Center was founded, much has been accomplished toward the goal of institutional change in the conduct of cognitive science. The members of the Center are now prepared to initiate a long-term effort toward the scientific and instructional goals they have set for themselves and for the field. The next five years promise to be among the most exciting of times for cognitive science at MIT. Several recent accomplishments are given below.

RESEARCH

Pre- and Postdoctoral Fellowships

The Center sponsored nine fellows this past year. In addition to the stimulus that these scholars provide to existing research programs, each fellow pursues his or her own research, participates in seminars, and may write one or more occasional papers while at MIT.

The success of the fellowship program, coordinated by Dr. Edward C. T. Walker, can be measured, in part, by a substantial increase in fellowship applications received in the past year. Research affiliates, who are appointed without stipend, are also selected from these applications. Six postdoctoral fellows and 12 research affiliates were accepted for 1981-82 due to the quality of the response.

Current Research

Semantic and Associative Relations in Pre-attentive and Attended Processing (Proposal pending, NSF; Co-principal Investigators: Jerry A. Fodor, Merrill F. Garrett, Edward C. T. Walker). The major theoretical impetus for recent research in semantic memory has been the contrast between models in which lexical entries are organized for recognition according to a hierarchical system of semantic features and those which attribute semantic relations to a network of meaning postulates. The five series of experiments proposed here use tasks which tap pre-attentive or attended processing to examine the effects of semantic and associative relationships among words presented in isolation and in sentences.

The Interaction of Sound and Knowledge in Word Recognition from Fluent Speech (Natural Sciences and Engineering Research Council of Canada; Jola Jakimik, Postdoctoral Fellowship). This research concerns several aspects of human listeners' knowledge about and processing of spoken words. Part of the work has been an investigation into the recognition of words from fluent speech, and has examined the nature of sound-based lexical retrieval. In a continuing series of experiments, the researchers have been examining the connection between knowledge of the written and spoken forms of words.

The Use of Intonation in Automatic Speech Understanding (NSF; Principal Investigator: Janet Pierrehumbert). Intonation, as expressed in the fundamental frequency of the voice, is related to the location of stress in words and to syntactic phrasing. This research is directed towards using the intonation system to help a computer system for understanding speech determine what words it has heard, and how these words are organized into sentences. It is anticipated that work in this area will contribute to making speech understanding systems good enough to be useful in many practical applications, and that the research will also add to the understanding of how people process speech.
From Shapes and Movements to Objects and Actions: A Functional Representation (Proposal pending, NSF, ONR; Principal Investigator: Shimon Ullman; Investigators: Lucia Vaina, K. Nishihara). The aim of this research is to examine the representational problems posed by adding simple notions of use, purpose, and function to the information obtained from the sensory analysis. The researchers refer to this representation as "functional representation" which is concerned with the recognition of: 1) actions which are purposeful movements and whose consequences can be visually identified and 2) objects which are visually describable shapes grouped by their function or use in actions.

Grammatical Representation and Grammatical Processing (NSF, sponsor; Joan Bresnan, Ronald Kaplan, Principal Investigators).

I. Grammatical Representation

Lexically Encoded Grammatical Relations. Bresnan has extended the work in "The Passive in Lexical Theory" (MIT Cognitive Science Center Occasional Paper #7, 1980) by supervising the research of graduate students and postdoctoral fellows at MIT on the following problems:

- a lexical theory of Navajo passives and incorporated pronouns (J. Roberts)
- the derivation of derived nominals (M. Rappaport)
- preposition stranding in passives and other constructions (S. Rothstein)
- passive structures in Malagasy and Tagalog (L. Travis)
- double object constructions in Bantu languages (A. Zaenen)

Operations on Predicate Argument Structure. Research in this area by Bresnan and by Grimshaw is still in progress. Grimshaw is writing up a study of subcategorization and phrase structure.

Control and Lexically Controlled Syntactic Binding. Kaplan and Bresnan have completed their work "Lexical-Functional Grammar: A Formal System for Grammatical Representation" (MIT Cognitive Science Center Occasional Paper #13), which gives a formal theory of control and syntactic binding as well as an analysis of "tough-movement" constructions.

Functional Structure and the Representation of Meaning. The goals of research in this area are to develop an explicit procedure for semantic interpretation mapping from functional structures to a model-theoretically interpreted language, and to determine whether constraints on possible meanings are characterized in terms of functional configurations. With respect to the first goal, Halvorsen has developed an original semantic interpretation procedure for lexical functional grammars, which he is now writing up ("An Interpretation Procedure for Functional Structures") to appear as an MIT Cognitive Science Center Occasional Paper. With respect to the second goal, Bresnan and Mohanan (a graduate student at MIT) have discovered a set of universal principles of bound anaphora that are formulated in terms of functional structures. These principles explain processes of reflexivization, obviation, and disjoint reference in a variety of languages, including Chinese, Norwegian, and English. To our knowledge, no unified account of these processes has yet been given in any linguistic theory. This work is being jointly written up by Bresnan and Mohanan.

II. Grammatical Processing

The Processing Component. Research on the processing component has been completed by Kaplan ("Active Chart Parsing," paper presented at the Sloan Conference on Modeling Human Processing Strategies, University of Texas at Austin, March 23-27, 1981) and by Kaplan and K. Church ("Eliminating Recursion in Phrase-Structure Based Grammars," paper presented at the Sloan Conference on Modeling Human Processing Strategies, University of Texas at Austin, March 23-27, 1981). While this work deals with the problems of parsing constituent structures, an important advance on the problem of processing functional structures has been made by a graduate student in artificial intelligence at MIT, Kelly Roach. Our group is now working with Roach on the integration of c-structure and f-structure processing.
Testing the Representational Theory through Psychological Research. Ford, Bresnan, and Kaplan ("A Competence-Based Theory of Syntactic Closure," MIT Cognitive Science Center Occasional Paper #14, 1981) have constructed and motivated a competence-based theory of syntactic closure which directly incorporates lexical functional grammars as representations of linguistic knowledge. A particularly interesting and important research problem in the development of a theory of sentence perception has been to explain the structural biases shown in structurally ambiguous sentences, since the effects observed have been assumed to reflect the operating principles of the human parsing mechanism very directly. The theory explains a variety of seemingly unrelated phenomena such as the lexical-expectation effect in gap-finding (Fodor 1978), garden paths (Bever 1970), "Minimal Attachment" (Frazier and Fodor 1978, Wanner 1980), and "Right Association" (Kimball 1973, Wanner 1980); see the Ford, Bresnan, and Kaplan study for these references.

Sentence Comprehension. The goals of our research on sentence comprehension include the development of methods for measuring within-sentence processing complexity in an efficient way, and experimental investigations of lexico-syntactic interactions and varying critical regions. Ford is now writing up the results of her experiments validating the Continuous Lexical Decision task. An On-Line experiment has been designed to determine at precisely what points during the processing of sentences in comprehension lexical information is used. Ford is also planning another on-line experiment to study varying critical regions in relative clauses. These experiments will be facilitated by the new PDP 1144 which the Cognitive Science Center Laboratory has just received, and by laboratory technician Alan Doyle, who was employed on December 15, 1980.

Sentence Production. No research has yet been carried out in this area, beyond the study by Ford ("Sentence Planning Units: Implications for the Speaker's Representation of Meaningful Relations Underlying Sentences") at the MIT Cognitive Science Center.

Conceptual Change in Children and Adult Scientists (NSF/NIE, sponsor; Principal Investigator: Susan Carey). This research project is based on the assumption that some of the kinds of conceptual changes that have been important in the development of scientific theories, especially in scientific revolutions, are also important in conceptual development in children. In particular, it is proposed that conceptual differentiation is an important kind of conceptual change that occurs in children as well as scientists and that in both cases differentiation must be seen in the context of theory change to be properly understood. Two extensive case studies of conceptual differentiation are currently being completed. In both cases, specific proposals about the nature of the undifferentiated and differentiated states are evaluated and characterizations of conceptual changes involving differentiation are distinguished from other kinds of conceptual change. The larger significance of this work is that it begins to provide an alternative framework for viewing conceptual development in children from that provided by traditional Piagetian theory.

Curriculum Development

Under the direction of Professor Osherson, the development of a "Map of Cognitive Science," funded by the National Endowment for the Humanities (NEH), has been underway for the past year. The map is a detailed guide to central theories and data in the field of language and mind, and includes such topics as natural language syntax, psycholinguistics, philosophy of psychology, cognitive neurology, mental representation, automata theory, and human information processing. Each of these topics is presented through an ordered set of readings with extensive annotation by the faculty in the Language and Mind Program. When completed, the map will offer all the information needed for the design or revision of language and mind courses in a way that can be easily updated as the field develops, and that will be readily accessible to people outside MIT.

Undergraduate Major in Cognitive Science

In a collaborative effort, the Departments of Linguistics and Philosophy, Psychology, and Electrical Engineering and Computer Science have been meeting to discuss the creation of an undergraduate major in cognitive science. The groundwork for such a possibility has been set up in the initial meetings and a detailed proposal should be ready by the end of summer 1981.
**CENTER ACTIVITIES**

**Multi-User Laboratory Facility**

The computer facility of the Cognitive Science Center was established approximately one and one-half years ago, with the acquisition of a small computer system capable of running experiments involving subject responses to visual and recorded auditory stimuli. Later, a larger computer was installed to form a nucleus around which the facility could grow further. This computer will be used as a timesharing facility on which programs can be developed for the small computer and the other small computers in laboratories associated with the Center. In addition, the large computer has the hardware to perform speech input/output and control X-Y CRT displays. Some subject stations can be built around this hardware, and the large computer can be used to run experiments. There will also be medium-speed links to other computers on campus such as the Research Laboratory of Electronics' DEC system-20 and a high-speed link to the local area network known as the MIT CHAOSNET.

At present, the facility consists of a Digital Equipment Corporation PDP 11/44, a PDP 11/03, a Terak 8510a graphics computer, an Apple II computer, and four communications ports on the DEC system-20 owned by RLE.

The Center has access to the DEC system-20 of the Research Laboratory of Electronics via four communications ports. Two of these ports are wired as dedicated terminals and operate at 9600 baud. These terminals are used by the Lexical Functional Grammar project. The remaining two ports are configured as dial-up lines and can be accessed by terminals at either 300 or 1200 baud. There are two terminals in the computer laboratory, one in the main office of the Center, and several at various other sites. These lines are heavily used and it is possible that more will have to be added in the near future.

One of the factors influencing the facility will be normal growth due to an increasing awareness on the part of the members of the Center of the potential of the facility in assisting them in their work. Another factor is the probable establishment of an undergraduate degree program in the Department of Psychology. Such a program would include the use of the computer facility as a tool in teaching research-oriented courses and in familiarizing the students with computers. Some of these needs will be covered by funds remaining in the NSF Multi-User Equipment grant which helped establish the facility. Some will require additional sources of funds.

The long-term demands placed on the computer facility by members of the Center undoubtedly will parallel the short-term demands which would arise by the inclusion of the undergraduate degree program. Thus, whether or not the psychology undergraduate degree program has access to the computer facility, the enhancements of the facility discussed in the previous sections probably will be required.

**Preparation of the Sloan Proposal**

One of the major activities of the Center was the preparation of a 400-page proposal to the Alfred P. Sloan Foundation for a Program Development Grant in Cognitive Science. The proposal included a 10-page narrative and 20 contributions from the working group members and affiliates of the Center, and a five-year budget for "Phase III" of the Center's development.

**Language Acquisition and Linguistic Theory Workshop**

During January 1981, a special workshop on language acquisition was held under the direction of Dr. Thomas Roeper, a visiting scholar from the University of Massachusetts at Amherst. The workshop was part of an effort by the Center to enhance training and research in this important subdiscipline of cognitive science.

**Occasional Papers**

This past year, eight contributions from members of the Center brought the total number of occasional papers to 17. These papers, which enable Center members to disseminate
Center for International Studies

their research results without the time lag associated with normal channels of publication, are distributed via a mailing list to over 200 interested subscribers.

Mental Representation Seminar Series

A biweekly seminar series entitled "Mental Representation" was held this past spring to give the Center's 1980-81 postdoctoral fellows an opportunity to present their research. The seminar's goal was to present the various information processing problems currently being examined by the fellows and at the same time to motivate general interest in the "big" question: How does the brain work?

SAMUEL J. KEYSER

Center for International Studies

During the past year, the Center for International Studies continued to work on contemporary public policy issues, primarily but not exclusively international, that have a significant technological component.

Under the direction of Professor Eugene B. Skolnikoff, Department of Political Science, the Center moved toward development of a major new program focused on risk management issues. This program will be co-sponsored by the MIT Program in Science, Technology, and Society (STS), and will explore such issues as: perception and presentation of risk, distributional questions, methodological problems, and professional education. Faculty from throughout the Institute have met during the year to develop a concrete agenda for a continuing faculty working seminar and the larger-range research program. This core faculty group includes, in addition to Professor Skolnikoff: Professors Richard L. De Neufville, Department of Civil Engineering; Alvin W. Drake, Department of Electrical Engineering and Computer Science; William H. Dunnouchel, Department of Mathematics; Joseph Ferreira, Jr., Department of Urban Studies and Planning; Ted R. I. Greenwood, Department of Political Science; Jeffrey E. Harris, Department of Economics; Carl Kaysen, STS; Marie-Elisabeth Paté, Department of Civil Engineering; Walter A. Rosenblith, Institute Professor; Harvey M. Sapolsky, Department of Political Science; Steven R. Tannenbaum, Department of Nutrition and Food Science; and Dr. Christopher T. Hill, Senior Research Associate, Center for Policy Alternatives.

This program was based in part on the Center's work on the environment and on toxic chemicals. During the past year, these two research programs, which were funded by the Andrew W. Mellon Foundation, dealt with three substantive issues, as well as general problems of the environment and of regulation of toxic substances. Dr. Subodh Mathur, postdoctoral fellow, and Professor Ann F. Friedlaender, Departments of Economics and Civil Engineering, looked at pollution and the environment as commodities that could enter international trade in a variety of ways, and explored how classical economics would interpret the interactions. Dr. Howard Margolis, postdoctoral fellow, worked on problems of "political cognition," which help to explain why a policy issue is viewed positively by some and negatively by others; he has drawn examples from fields such as the environment, arms control, and defense policy. The third area of research, which is still underway by Professor Jerome Rothenberg, Department of Economics, compares the ways in which members of the Organization for Economic Cooperation and Development deal with toxic chemicals issues. During the year, work has also continued on producing a volume of original essays by leading spokesmen from many fields -- philosophy, science, humanities, sociology, history -- on visions of "the end" in Western thought. The idea grew out of interest in relating current concerns about ecological disaster to how humanity has faced impending or assumed catastrophic change in the past. This volume is being edited by Professor Saul Friedlander, Hebrew University of Jerusalem, with Professors Skolnikoff, Gerald Holton, Harvard University, and Leo Marx from STS, as coeditors. The book will be published in 1982 by Holmes & Meier.

Closely related to the programs previously described has been the comparative study being made by Professor Greenwood of the ways in which two major US agencies -- the Occupational Safety...
and Health Administration (OSHA) and the Environmental Protection Agency (EPA) -- respond to and use scientific information. How, for example, do they deal with uncertainty? How is scientific information sought out and utilized? Professor Greenwood's work has been supported in part by the White House Office of Science and Technology Policy.

Arms control and defense policy remained major components of the Center's program during the past year. Principal emphasis continued to be placed on supporting faculty and graduate students in a strong teaching program in these fields, centered in the Department of Political Science. Professor Jack P. Ruina, Department of Electrical Engineering and Computer Science, heads the program; other key participants are Professors William W. Kaufmann, Stephen M. Meyer, and George W. Rathjens, all of the Department of Political Science; Richard Lester, Department of Nuclear Engineering; Dr. Margolis; Dr. Gerald Steinberg, postdoctoral fellow; and Ms. Amelia C. Leiss. Two visiting scholars at the Center made major contributions during the past year: Dr. Anselm Yaron, Department of Defense, Israel, and LTC Richard Hodgkinson, US Air Force.

The program has as one of its major themes the US-Soviet strategic balance and how it is affected by technological change. Another major research theme has been nuclear proliferation. Additional research during the past year included a study of Soviet decision making on weapons procurement; the effect of US export control of dual-use technology on the capacity of an industrializing developing country to create an indigenous capacity to produce technologically sophisticated weapons systems; and the economic and other constraints and benefits of efforts of the more advanced developing states to develop technologically complex arms industries. This last project was carried out jointly with the Center for Policy Alternatives and coauthored by Dr. K. Nagaraja Rao, senior research associate, Center for Policy Alternatives.

The arms control and defense policy program received its principal support from the Ford Foundation, with funding for specific projects received from the United Nations and the US Arms Control and Disarmament Agency. The Ford Foundation also funded a conference in Budapest organized by Professor Hayward R. Alker, Department of Political Science, to assess the contribution of scientific social science to war avoidance.

The Center continued over the past year to be actively involved in the MIT Research Program on Communication Policy, together with the Center for Advanced Engineering Study, the Center for Policy Alternatives, the Laboratory for Computer Science, and the Laboratory for Information and Decision Systems. Professor Ithiel de Sola Pool, Department of Political Science, led the Center's part in the program. A major effort to raise general support funds for the program resulted in the past year with the addition of one faculty position in the field, Professor W. Russell Neuman, Department of Political Science.

Funds have also been raised for a major four-year multi-country study of the potential use of remote satellite broadcast systems to bring vital information on agricultural development to isolated rural areas. The objective of the research, which will be sponsored by the US Agency for International Development and will be carried out in conjunction with Abt Research, Inc., will be to determine whether this communication medium can be a cost-effective means of reaching segments of isolated rural populations in developing countries that frequently fall outside national development efforts, or can be reached only at great cost. This study will draw upon work that was done by Professor Pool on rural communication in Egypt, under the MIT Technology Adaptation Program.

Other studies conducted by the Center as part of the communications program include the effects of TV violence on children and the potential benefits of a Boston cable TV system. The program had multiple sponsors: American Telephone and Telegraph, International Business Machines, Hughes Aircraft Corporation, Citibank, the Sloan Foundation, the Markle Foundation, and the City of Boston.

Energy policy has remained a focus of Center research. With a major endowment from the Ministry of Foreign Affairs of Japan, the Center and the MIT Energy Laboratory have launched a number of inquiries, including a study of energy cooperation between the US and Japan by Professor Lester, and research on energy policy in Japan by Professor Richard J. Samuels, Department of Political Science. Other work on international oil and uranium markets carried out within the International Energy Policy Studies Group of the Energy Laboratory was funded by the endowment. In addition, another in a series of bilateral meetings on nuclear energy policy, including nuclear proliferation concerns, was held, this one with Japan. The meetings bring together individuals
from government, industry, and the universities to discuss major nuclear energy policy issues. This last session was funded by the Rockefeller Brothers Fund.

Plans have been made during the last year to develop at MIT a new program on Japan. The focus would be on Japanese management, research and development, and industry; it would attempt to introduce MIT undergraduates to Japanese culture and society — with opportunities, particularly for engineering students, to spend time in Japanese industry and laboratories to understand Japanese approaches to innovation, productivity, and similar matters. Professor Samuels has developed and directed the effort, which will involve many parts of the Institute when fully implemented. At present, the Center is serving as the coordinator.

The International Nutrition Program remains an active Center concern. This effort is sponsored jointly with the Department of Nutrition and Food Science, and has close relations to the United Nations University World Food Program. During the past year, a symposium was conducted for anthropologists on techniques for assessing nutritional status in the field. Work continued on a study of staple foods, and plans were being formulated for work on more effective utilization of currently wasted fish resources to improve the supply of protein in developing countries. The principal individuals involved in this program are Professors Nevin S. Scrimshaw, Institute Professor, and Lance J. Taylor, Departments of Economics and Nutrition and Food Science; Dr. Mitchell B. Wallerstein, Department of Nutrition and Food Science; and Dr. E. Raymond Pariser, Sea Grant Program.

In the International Business Project, directed by Professor Richard D. Robinson, Sloan School of Management, two studies proceeded during the past year. Professor Daniel M. Holland, Sloan School of Management, continued to direct the study that has been underway for several years on measuring the rate of return to capital. This effort to find a single, generally acceptable measure will greatly facilitate comparative study. A volume is being prepared for 1982 publication. Dr. Stephen Kobrin, New York University, completed a study on how multinational corporations assess political risk; it will be published in 1981. Funds for the International Business Project were received from John Deere, Caterpillar Tractor, Pfizer, Morgan Guarantee Trust, International Business Machines, IBM World Trade, Merck, Unilever, Universal Oil, Nestlé, and St. Gobain.

In a separate program, Professors Michael J. Piore, Department of Economics, and Charles F. Sabel, STS, continued a comparative study of the relationship between labor management relations and the general performance of the economy. The German Marshall Fund of the United States has supported this research.

Issues relating to development remain important parts of the Center’s program. Professor Nazli Choucri, Department of Political Science, has continued her work on migration among the Arab countries of the Middle East; her work has support from the Rockefeller Foundation-Ford Foundation joint program on population and the National Institutes of Health. The Rockefeller Brothers Fund supported a study by Professor Lucian W. Pye, Department of Political Science, on the differing ways various Asian societies have responded to modernization on transportation, education, and communication.

As a general contribution to the development community, the Center has provided support for the Joint Harvard University-MIT Seminar on Political Development — cosponsored with the Harvard Center for International Affairs and cochaired by Professor Myron Weiner, MIT Department of Political Science, and Professor Samuel Huntington, Harvard University. Also supported are faculty-student seminars on South Asia and on migration; the latter two are organized by Professor Weiner and all three draw their membership from the Cambridge-Boston university community.

Professor Alker completed a major study on reflective logics for resolving international insecurity dilemmas. The study examines a number of conflict situations — from abstract “prisoner’s dilemmas” to real international crises — in which short-term and long-term interests appear to conflict. This study was supported by the National Science Foundation.

The Center has jointly sponsored, with the Center for Transportation Studies, a major international comparative study on the Future of the Automobile. Professor Alan A. Altshuler, Department of Political Science, is co-director of the project and leads the Center’s participation. The program, carried out jointly with research teams in Japan, France, England, and Germany, is coming to grips with a host of economic, political, and technological issues associated with the automobile
industry: effects on international trade, concentration in the industry on protectionism, international production, cost competition, and other issues. The core costs of the project are funded by the German Marshall Fund; other support is provided by the Lilly Endowment, the US Departments of Transportation and Energy, and by the various national governments for their own teams.

As in the past, the Center continued to work closely with other parts of the Institute. In addition to the Center for Transportation Studies just mentioned, close contact has also been maintained with the Energy Laboratory, the Center for Policy Alternatives, the Technology Adaptation Program, and STS. Similarly, the Center has close working ties with the Center for Science and International Affairs, the Center for International Affairs, and the Center for West European Studies at Harvard University.

The Center conducts an extensive series of seminars for the MIT community and publishes a research monograph series. Each year the Center also sponsors visiting scholars working in fields relevant to Center research. Last year, scholars in residence for all or part of the year came from Israel, India, Turkey, Japan, Indonesia, UNESCO, the University of Denver, Wellesley College, the US Air Force, New York University, and Case Western Reserve University.

EUGENE B. SKOLNIKOFF

Center for Materials Research in Archaeology and Ethnology

The 1980-81 academic year was the fourth year of operation for the Center for Materials Research in Archaeology and Ethnology (CMRAE). Activities focused on two areas: graduate education of students from the seven participating universities, and research in the general domain of standards for the analysis of archaeological materials.

The Center offered a full-year graduate subject, "Biological Materials in Prehistory," to 15 students from six of its member universities, making a total of 110 students -- graduate students and senior undergraduates -- who have enrolled in CMRAE subjects since the Center's founding. Our offering this past year was specially designed and taught by four faculty members from four different CMRAE institutions: Professors Lawrence Kaplan, Professor of Biology, University of Massachusetts, Boston, and Gerald Kelso, Assistant Professor of Anthropology, Boston University; Dr. Richard Meadow, Research Associate in Mid-Eastern Archaeology, Harvard University; and Professor Wilma E. Wetterstrom, Assistant Professor of Archaeology, MIT. These faculty members were present at every seminar meeting and at every formal laboratory session during the year, so that students had the benefit of the different specialties each represents within the discipline of archaeology: palaeobotany, palynology, zooarchaeology, and palaeoethnobotany. This faculty designed its subject in a new and unusual way, providing students with a sense of a society's biological environment as a whole, to avoid treating ancient floral and faunal populations separately, as is generally the case when teaching students the theory and methodologies of zooarchaeology and palaeobotany. By integrating the two, the CMRAE faculty sought to establish for its students the nature of a biological environment and the interactions of human beings with that environment -- all as interpreted from archaeological evidence. One of the most exciting outcomes of the CMRAE subject was the decision by all four faculty members to author a book on biological materials in prehistory which will be based, in large part, on the syllabus and the laboratory methods designed during the past year's offering.

For their research projects, several students worked on collections they had excavated; others studied materials in the collections of the Peabody Museum of Archaeology and Ethnology at Harvard University; still others conducted experiments designed to refine laboratory procedures used in the retrieval and extraction of biological materials from the soils in which they have been deposited. Several students will continue their research projects during the coming academic year, using the facilities of the Center's graduate laboratory.

Another outcome of this year's graduate subject has been the establishment of a good basic reference collection of faunal and floral materials, which is a permanent part of the Center's
rapidly expanding assemblage of archaeological reference materials of many kinds, including metal, ceramic, and rock. We also established an excellent thin section facility, built and operated by Christopher A. Craig, technical instructor in the CMRAE laboratory, which has enabled him and Dr. Meadow to begin a long-term research project on the comparative morphological characteristics of fossil and fresh bone.

One purpose of the fossil bone morphology research project is to provide the archaeological profession with reference standards -- both samples and analytical interpretations of such samples -- against which to compare specimens of interest to archaeologists and physical anthropologists. The project is yet another sponsored by CMRAE in its efforts to provide materials analysts in archaeology with the standards and reference materials they need. A longer-standing project, which was continued during the course of the past year under the direction of Professor Kaplan, has involved the characterization of plant phytoliths (silica bodies) and their usefulness in reconstructing certain aspects of prehistoric floral environments. Professors Kaplan and Wetterstrom hope to continue their phytolith research during the next two years. The Center has applied to the National Endowment for the Humanities for a grant to continue funding for the project. The research will be carried out at the appropriate Center laboratories at MIT and the University of Massachusetts, Boston.

With a view, in part, to stimulating the Center's growing research involvement in the fields of palaeodiet, palaeonutrition, and the reconstruction of prehistoric biological environments, CMRAE co-sponsored a colloquium series with the Anthropology-Archaeology Program that took place during both semesters. "New Perspectives In Physical Anthropology and in Ceramic Archaeology" brought six scholars to MIT to discuss the newest developments in these two fields.

HEATHER N. LECHTMAN

Committee on the Visual Arts

COMMITTEE ACTION

The Committee on the Visual Arts (CVA), a presidentially appointed body composed of faculty, administration, and student members, oversee policy for an energetic, non-curricular program in the visual arts which is administered by a professional staff. The CVA is charged with a broad spectrum of responsibilities: the organization of the Hayden Galleries' exhibition and publication program, the development and curatorial care of a growing permanent collection as well as two student loan collections, and the sponsorship of a variety of educational activities designed to elucidate salient issues in contemporary art. Since all of its activities are open to the general public as well as to members of the MIT community, the CVA contributes significantly to the cultural vitality of the region. Indeed, the adventurous and superlative quality of the gallery and the acquisition programs has garnered national attention.

The CVA's focus mirrors MIT's position on the leading edge of scientific and technological enquiry; its program is committed to the exploration and explication of contemporary painting, photography, sculpture, and architecture, as well as to those activities which bridge traditional distinctions between these mediums. Both the acquisition and exhibition programs focus on innovative work by promising, as well as established, artists and often, though not exclusively, highlight aspects of the fruitful cross-fertilization between art and technology.

The Committee met 10 times during the 1980-81 academic year. A primary concern was to establish the procedures and criteria for the purchase of artworks with the one-percent-for-art allowances associated with 500 Memorial Drive, 70 Memorial Drive, One Amherst Street, the Athletic Facility, and the Whitaker Building for Health Sciences, Technology, and Management. Prior to arriving at a list of artists whose work was considered both desirable for inclusion in the permanent collections and appropriate to the available sites, the Committee discussed a number of related issues: the definition of public spaces for which art was to be purchased; the prudence of pooling all or most of the available funds in order to purchase one major sculpture by an artist comparable
in stature to Henry Moore, whose bronze figure graces Killian Court; and the creation of a conservation fund for the maintenance of all future acquisitions through the allocation of 10 percent of all one-percent funds. It generally was agreed that seminar, conference, and reception areas— as well as lobbies, corridors, and outdoor sites— were appropriate public areas for new acquisitions; private offices, however, would not necessarily benefit from the one-percent-for-art allowance. While the acquisition of a major work by contemporary masters such as David Smith was deemed highly desirable, the Committee decided the one-percent funds would best be spent to purchase a larger number of works by promising artists. However, the Committee voiced hopes that the acquisitions committee of the Council for the Arts would assist in soliciting donations of work by contemporary masters, the cost of which could not be absorbed by one-percent funds. The Committee agreed unanimously to allocate 10 percent of the one-percent funds for a conservation fund, which would be pooled and spent as required on future conservation needs, since the conservation needs of all past acquisitions would continue to be covered by funds now included in the CVA and Physical Plant budgets.

In June, the Committee was notified by the senior administration that the five current, major construction and renovation projects on campus were underfunded, requiring a reconsideration of the one-percent-for-art allowance. While the administration's commitment to future art allowances for fully funded buildings was stated clearly, the one-percent allowance was abrogated for three of the five present projects. One-percent funds were allocated fully for the design and construction of the new dormitory garden at 500 Memorial Drive by sculptor George Trakas. Trakas' proposal was selected by the Committee after reviewing fourteen other artists' work, four of whom were asked to submit proposals based on a program prepared by students, the Dean for Student Affairs Office, and the campus architect. The one-percent allowance for the Athletic Facility also remained, allowing the Committee to apply for matching funds from the National Endowment for the Arts in order to commission a sculpture by Richard Serra. Approval of the grant is still pending. Two proposals requested in the previous year by the Committee from photographer Peter Campus and sculptor Gary Wiley for commissioned works of art for the Animal Care Facility, received final approval and are being implemented.

Other issues discussed by the Committee included the use of Hayden Gallery by groups not associated with MIT, as well as those sponsored by the Institute; the programmatic and spatial possibilities of the proposed Arts and Media Technology Facility; and the expansion of the two student loan collections.

PERMANENT COLLECTION

The MIT collections, comprising the permanent collection and two student loan collections, consists of over 1,000 works of art. The primary focus is on contemporary sculpture, painting, and works on paper.

New Installations and Sitings

A bronze sculptural relief, Birth of the Muses, by Jacques Lipchitz, on loan to the permanent collection from Yulla Lipchitz, was sited outside the northeast entrance to the Hayden Memorial Library Building in December 1980. A large neon sculpture by Chryssa, together with a major painting by Jack Bush and a suite of prints by Brice Marden, was sited in the early fall in the headquarters of the Research Laboratory of Electronics. Paintings and works on paper were hung in numerous sites throughout the Institute, including several offices of the Dean for Students, reception and work areas of Student Financial Aid, Design Services, the circulation area of Barker Engineering Library, the headquarters of Physical Plant reception areas, the Council for the Arts offices, the office of Sustaining Fellows, the President's office and house, the Provost's office, and the offices of the Assistant Provosts. Works were also hung in the new offices of Professors Jerome B. Wiesner and Walter A. Rosenblith.

Because of the demands relating to the siting and care of the permanent collection, policy was initiated whereby requests to hang works of art owned by individuals would be granted at a charge of $20.00 per hour.
Committee on the Visual Arts

Four paintings by 18th and 19th Century American masters, given to the permanent collection by I. Austin Kelly, were presented together for the first time in a temporary exhibition held at the MIT Museum and Historical Collections during June. The exhibition was mounted on the occasion of the 55th class reunion of the Class of 1926, of which Mr. Kelly is a member.

Loans to Other Institutions

A painting by Thomas Hart Benton, *Fluid Catalytic Crackers*, was included in the major exhibition of American painting between the wars, "Amerika: Trauma and Depression, 1920-1940," from November through December 1980 at the Akademie der Kunste in Berlin, West Germany, sponsored by the Neue Gesellschaft fur bildende Kunst, and from January through April at the Kunstverein in Hamburg, West Germany.

Conservation

The conservation survey of the MIT permanent collection, funded by a grant from the Institute of Museum Services, was completed with the professional staff of the Fogg Museum Center for Conservation and Technical Studies. On the basis of that survey and an increasing awareness of the critical need for a conservation program for the permanent collection, an allocation in the CVA operating budget was made for the first time in the past year for conservation of painting and works on paper in the permanent collection. Using the results of the survey as a guideline for establishing priorities, a number of works on paper were reframed using archival materials. The remainder of the funds, coupled with a grant from the Neue Gesellschaft fur bildende Kunst in Berlin, were used for the restoration of the Benton painting, *Fluid Catalytic Crackers*.

A similar allocation for conservation of the outdoor sculpture collection was made through the Physical Plant budget. These funds, coupled with a grant from the Council for the Arts, enabled the permanent installation of *Dunes 1* by Beverly Pepper.

Vandalism

Several glass panels of *The Iceberg and Its Shadow* by Larry Bell, installed in the Bush Lobby, Building 13, were chipped during the past year and one panel was damaged severely, necessitating the removal of the sculpture from the lobby. A reevaluation of means to minimize possible damages to the sculpture while installed in public areas is underway currently, and will be completed before the sculpture is again sited.

EDUCATIONAL PROGRAMS

The Committee organizes a wide range of educational activities intended to broaden awareness of an artist's historical context, working methods, and professional concerns, and to underscore parallel modes of artistic and scientific investigation.

List and Stratton Student Loan Programs

The annual Hayden Gallery exhibition of framed prints and posters from the Catherine N. Stratton Collection of Graphic Art and the List Student Loan Program consisted of 180 art works. (An additional 32 were donated to the program during the past year and funds were raised to frame 15 prints given previously.) Over 830 students and 38 student groups vied for borrowing privileges, for which there is no charge. The popular program provides direct and daily contact with objects of aesthetic excellence and is designed to encourage habits of critical vision and a life-long involvement with the visual arts. The only complaint heard from students stemmed from the relatively small number of available art works.
IAP and Artist-in-Residency Project

In conjunction with the Hayden Gallery "Rooms" exhibition, artists Richard Artschwager, Cynthia Carlson, and Richard Haas spent one week in residence overseeing the construction of their installations and discussing their work with visitors, which included critics, faculty members of local educational institutions, artists, and students. They were assisted by student volunteers from Hunter College and Bennington College, as well as a student from the Department of Mechanical Engineering, who designed the electronic component of one of the installations. The construction process was documented and included in a videotape, which also contained interviews with the artists in their New York City studios. The tape played during the exhibition. On January 16, each of the three artists gave a slide presentation of their work and participated in a panel discussion. The talks were attended by over 250 people. A planned workshop dealing with the proper techniques for matting and framing art works was cancelled due to little interest on the part of the community. The workshop had been suggested by an MIT employee.

Tours and Gallery Talks

The staff continued to offer gallery talks, slide presentations, and walking tours of the permanent collection to any interested group, including collectors and museum professionals from the Museum of Modern Art in New York, the New Gallery in Cleveland, Ohio, and the South Shore Art Society in Massachusetts. Students and their professors from the Museum School, Tufts University, and MIT also met with the curatorial staff, as did members of the Technology Wives Group and employees of the Institute. Lectures and talks were prepared for members of the Fogg Art Museum and the Institute of Contemporary Art.

The permanent collection was the focus of study for students from Tufts, Suffolk, Harvard, and Boston universities, as well as Boston, Bennington, Wheaton, Emerson, and Wellesley colleges.

The Walking Tour

Funding from the National Endowment for the Arts continued, allowing the coordinator of Special Projects to complete her draft of this guide to MIT's visual environment. Completion of the guide is intended for fall, 1981.

Volunteers and Interns

A part-time volunteer continued to assist the Registrar. Three part-time interns from the State University of New York (SUNY) at Binghamton, Wheaton College, and Bennington College worked with the curatorial staff and gallery manager in preparing exhibition materials. Inquiries for future internships have been received from students at Tufts University, the University of Cincinnati, Connecticut College, and Brandeis University.

Video and Slide Resources

Original videotape documentations designed to enhance the audience's understanding of the exhibiting artists' concerns were produced for two exhibitions, "Jonathan Borofsky: An Installation 2699475," and "Rooms." The videotapes, which played in Hayden Gallery during the exhibitions and over the MIT and Harvard cable television systems, are housed in Rotch Visual Collections and cross-referenced in Rotch Library to encourage reference use. These two tapes, as well as those produced previously, were screened publicly at the Harvard University Graduate School of Design, MIT Film-Video Section, the Boston Film Video Foundation, and the Kitchen, an alternative exhibition space for video and performance art in New York. The assistant curator presented the videotapes at a conference sponsored by the New England Museum Association on the use of video technology for museums. A group of film and television professionals, who are involved in planning for community access to cable television, have asked the Committee to compile a sample Hayden Gallery tape from its video archives, to be used as an integral part of their arts programming.
Committee on the Visual Arts

Editing and production services again were contributed by Educational Video Resources. Additional support was received from the National Endowment for the Arts. All videotapes were directed by Bernice Schneider, a part-time instructor in the Film-Video Section.

Publications and Public Information

In support of the Hayden Gallery and Hayden Corridor Gallery program, various educational publications were produced. Extensive explanatory wall texts were posted prominently for each of the 12 exhibitions. Catalogues were produced for "The Material Object," "Rooms," and "Furniture by Architects" exhibitions. A "Four Painters" catalogue currently is in production. A brochure was produced for "Jonathan Borofsky: An Installation 269475." A number of companies and bookstores have undertaken the international distribution of CVA publications.

An illustrated brochure detailing the Committee's programs was produced and has become an invaluable aid to providing information on its activities.

Press releases for exhibitions and activities were prepared by CVA staff as publicity and educational support. Posters for Hayden Gallery exhibitions and postcards for Hayden Corridor Gallery exhibitions were distributed throughout MIT and to an increased mailing list of 3,600. The MIT Press bookstore currently is selling some of these posters. Posters, postcards, and catalogues were designed by Jacqueline Casey, director of MIT's Design Services. Numerous posters won design awards and were exhibited at museums, such as the Cooper Hewitt in New York, and in international competitions. Reviews of Hayden Gallery exhibitions and CVA activities appeared in such publications as the Boston Globe, Art New England, the Christian Science Monitor, New Art Examiner, Design at Northeastern, Progressive Architecture, Art in America, Take It, and the MIT publications, Tech Talk, The Tech, and the Link. The Borofsky exhibition was singled out by the Boston Globe art critic as one of the most significant exhibitions of the year. A press book containing all reviews is kept in the CVA office.

Proposal Preparation

In order to support and expand the CVA's programs, a number of grant applications were prepared. Exhibitions were supported by the National Endowment for the Arts, the British Council, the Knoll Foundation, and the MIT Inauguration Committee. The student loan programs received assistance from Albert and Vera List, Luis Ferre, the Taylor Family Endowment, the Engineering Student Art Loan Fund, Mitchell Silverstein, and Alan May of the Dallas Community Chest Trust Fund.

In order to support next year's program, applications were made to four departments of the National Endowment for the Arts, the Institute of Museum Services, the Massachusetts Council on the Arts and Humanities, the New England Foundation for the Arts, and the MIT Council for the Arts.

EXHIBITION PROGRAM

In 1980-81 the Hayden Gallery continued one of the area's most active exhibition programs in contemporary art. It is designed to acquaint both the MIT community and the New England region with challenging, innovative work in painting, sculpture, photography, architecture, and design by both local and internationally based artists.

The 12 exhibitions in the Hayden Gallery and the Hayden Corridor Gallery were all organized and mounted by the CVA staff. They attracted an audience of over 20,000, continuing an encouraging annual upward trend. Each exhibition opened with a public preview; many of the participating artists attended. The Hayden Corridor Gallery is open continuously for the benefit of the heavy stream of traffic through Building 14; the Hayden Gallery is open free of charge seven days a week from 10 am to 4 pm and on Wednesday evenings from 6 to 9 pm.
Schedule for 1980–81

The Past as Prologue: Planning and Building at MIT, Hayden Corridor Gallery, September 2 – October 5, 1980. This exhibition was organized in honor of the inauguration of Dr. Paul E. Gray as 14th president of MIT. It documented, through renderings, plans, maps, photographs, and original drawings, the physical changes in the Institute campus. Site use and building design, as well as their relationship to changing MIT administrative visions and the evolution of teaching and research programs, were examined. The popularity of the exhibition led to its subsequent permanent installation at Historical Collections.

List and Stratton Student Loan Collections, Hayden Gallery, September 8-26, 1980. Framed 20th-Century works on paper from the Catherine N. Stratton Collection of Graphic Art established in 1966, and from the List Student Loan Collection begun in 1977, were shown prior to being distributed by lottery to MIT students and student groups. A wide variety of trends and techniques in recent printmaking are represented.

The Material Object, Hayden Gallery, October 11 – November 16, 1980. Sculptures by Tom Bills, John Gibbons, Roni Horn, and Nicholas Pearson. Small-scale works by four young sculptors were shown for the first time in Boston. A departure from recent installation-oriented Hayden Gallery sculpture surveys, this exhibition focused on the creation of discrete objects independent of architecture, history, literature, or other external references. The exhibition was supported in part by the British Council, London.

Aaron Fink: Works on Paper, Hayden Corridor Gallery, October 11 – November 16, 1980. This young Boston painter showed more than 30 works in acrylic, charcoal, gouache, crayon, and tempera. The drawings take up certain themes -- cherries, cigars, waves, clouds, a lone smoker -- and rework them with a robust, expressionist gesture. The exhibition was held in conjunction with Artweek, a Boston area celebration of the arts.

Jonathan Borofsky: An Installation 2699475, Hayden Gallery, December 2-24, 1980. This installation provided the region with the first comprehensive look at the multilayered, visually cacophonous approach of this California-based but Boston-born artist who has received considerable recent critical attention. Borofsky's highly personal environments explore conceptual, surrealist, and expressionist currents with their origins primarily in the artist's dreams and automatic drawings.

Phillip Galgiani: Studio Photographs, Hayden Corridor Gallery December 2, 1980 – January 11, 1981. Unlike documentary photographers who record or comment on aspects of the outside world, Galgiani contrives environments or situations in his studio, grouping common objects to conform to the needs of his photographs. The exhibition was the first showing in Boston of the San Francisco artist's work.

Rooms: Richard Artschwager, Cynthia Carlson, Richard Haas, Hayden Gallery, January 17 – March 1, 1981. "Rooms," an exhibition of three installations, explored the relationship between architectural space and painted or sculpted illusion, and reflected each artist's personal response to the MIT environment. Artschwager constructed a narrow, woodgrain formica chamber ambiguously identifiable as either office or elevator. Cynthia Carlson's "kitsch imported period room" consisted of two rooms joined by a long corridor, the whole wall papered in flowers of squeegeed latex and flatly rendered silhouette. Richard Haas designed a trompe l'oeil "Pantheon of Honor," an illusionistic domed atrium inspired by the original Beaux-Arts architecture of MIT, with pseudo-engraved names of notable figures from the Institute's history. The exhibition was supported, in part, by a grant from the National Endowment for the Arts.

Artists' Gardens and Parks, Hayden Corridor Gallery, January 17 – March 1, 1981. As artists' projects outgrew the contained boundaries of gallery space, a number of artists turned their attention to the outdoor environment. The exhibition of plans, drawings, and photographs documented recent projects by artists who created functional garden contexts rather than either earthworks or autonomous art works within a landscape setting. The artists represented were Noguchi, Dubuffet, Athena Tacha, Sol Lewitt, Richard Fleischner, Nancy Holt, Martha Schwartz, Gary Rieveschl, Andrew Leicester, George Trakas, Mary Miss, Stuart Wrede, Robert Irwin, and Roelof Louw. The exhibition subsequently traveled to the Museum of Contemporary Art in Chicago, and will circulate to a number of other museums under the auspices of the Ohio Foundation for the Arts.
Division for Study and Research in Education

Four Painters: Carroll Dunham, Ralph Hilton, John Kohring, and Carol Lindsley, Hayden Gallery, March 14 - April 26, 1981. Like its companion, "The Material Object" sculpture show, the painting exhibition focused on new work by four artists little known to the public. The paintings included represented diverse working methods and a variety of approaches to abstraction.

Robert Einbeck, Hayden Corridor Gallery, March 14 - April 26, 1981. An interrelated series of 14 large-scale works on paper by this Parisian artist were shown for the first time in the United States. The suite of drawings was designed specifically for the Hayden Corridor Gallery. Conceived as an aide to meditation, the paintings exploit subtle sequential changes in repeated abstractly colored elements, to which the viewer is encouraged to react intuitively.

Furniture by Architects, Hayden Gallery, May 15 - June 28, 1981. This exhibition was the first in the country to bring together a group of objects -- tables, chairs, and lamps -- which represent the variety of contemporary approaches to furniture form, function, and materials. Among the established architectural talents represented were Michael Graves, Richard Meier, Emilio Ambasz, Frank Gehry, Arata Isozaki, and the local partnership of Machado and Silvetti. Younger architects included Tod Williams, Billie Tsien, Craig Hodgetts, and Robert Mangurian. The exhibition was supported, in part, by the Knoll Foundation.

Furniture by Architects: 20th-Century Precedents, Hayden Corridor Gallery, May 15 - June 28, 1981. This photographic documentation of radical and innovative work by architect-designers from the Art Nouveau period through the late 1950s, was conceived to establish the historical context for the accompanying Hayden Gallery survey of contemporary activity in the field. Influential designs by Frank Lloyd Wright, Mackintosh, Breuer, Rietveld, LeCorbusier, Aalto, Saarinen, and Mies van der Rohe were included.

BORIS MAGASANIK
KATHY HALBREICH

Division for Study and Research in Education

The past academic year 1980-81, the eighth operational year for the Division for Study and Research in Education (DSRE), has been a productive and satisfying one. As this report will describe with a brief synopsis, the program for graduate students has been reinforced by the addition of a "core" course. The Division has provided a forum for discussion of undergraduate education in physics and mathematics at the Institute. Faculty research has matured, while granting agencies, governmental and private, have continued to express confidence in that research with support in excess of half a million dollars during fiscal year 1981.

A review of statements about the Division since its formation discloses the persistence and integrity of a central set of intellectual concerns: the disciplined study of learning processes; the learner and the learning mind engaged in real work in natural settings as object of scrutiny; the dynamics of the learner's informal, intuitive knowledge and the structured knowledge of the classroom, and the representational strategies that the learner employs to mediate between the two universes; the affective force fields that bear upon learning and may be implicit in the social or institutional context, in individual teaching practices, in language -- and the conviction that the mysteries of learning are so rich and diverse as to demand the talents of a broad interdisciplinary team in their unraveling. These concerns have provided a solid intellectual base upon which the Division has built academic and research activities -- activities which have compelled the attention of a gradually but steadily expanding network of scholars and educators from MIT and elsewhere.

While sustaining what have by now become regular activities, the Division during the past year extended its involvement with various aspects of the MIT educational effort.

1) Professor William T. Martin, Professor of Education and Mathematics, Emeritus, DSRE, instigated a forum to discuss the MIT freshman requirement in Physics and Mathematics. Professor Martin moderated a panel consisting of Claude R. Canizaros (Associate Professor of Physics,
Undergraduate Physics Education Committee), Daniel J. Kleitman (Head, Department of Mathematics), R. Duncan Luce (Alfred North Whitehead Professor of Psychology, Harvard University), Arthur P. Mattuck (Class of 1922 Professor of Mathematics), Philip Morrison (Institute Professor), Henry O. Pollak (Director, Mathematics and Statistics Center, Bell Telephone Laboratories), Robert Resnick (Professor of Physics, Rensselaer Polytechnic Institute), and Sheila E. Widnall (Professor of Aeronautics and Astronautics, Chairman of the Faculty and the Committee on Educational Policy). The participants took as their topic of discussion the present freshman subjects in physics and mathematics, which are based primarily on the classical continuum of Newtonian mechanics and the differential and integral calculus of one or more continuous variables -- all analytic, closed-form studies of a small number of continuous variables. The group considered the possibility that this classical outlook may be too narrow for a world in which the entry of numerical, discontinuous, and discrete concepts -- including probability, instabilities, nonlinearities, and simulation are basic to many scientific and mathematical investigations. At MIT these latter ideas enter students' lives strongly after their freshman year.

The very obvious success of the forum, both as an immediate intellectual event and as a catalyst for further examination of the freshman program, suggests the future of similar carefully composed gatherings under DSRE auspices.

2) Margaret L. A. MacVicar, Associate Professor of Physical Science, held the appointment as Cecil and Ida Green Professor of Education in DSRE. Professor MacVicar's time in the Division enabled her to concentrate energies upon her twelve-year case study of the MIT Undergraduate Research Opportunities Program (UROP), and to consult with various Division faculty, particularly Professors Benson R. Snyder and Barbara Scott Nelson, whose respective research interests in the MIT social context and in educational innovations are long-standing. Professor MacVicar presented some of her work at the Division's luncheon seminar series in a talk entitled "UROP after 12 Years: Reflections of an Institution."

Meanwhile, she joined Professors Martin, Snyder, and Nelson in the preliminary design of a program for a "Faculty Education Network (FEN)." FEN is conceived as a support system for MIT educators, a flexible program through which faculty members might be provided with "released time" to work on a subject modification, or with materials to try something new, or with chances to discuss teaching-related problems with others.

3) Three new courses developed by DSRE faculty -- one offered during the spring term 1981 and the other two scheduled for fall -- deserve special mention because they cut across a number of Institute interests. This past spring Professor John Richards held a graduate seminar to study the "Construction of Mathematical Knowledge." The course integrated Piagetian-style research on the genesis of number in the child with philosophical investigations into the constructive nature of mathematics. Examples from an ongoing interdisciplinary research project on the formation of whole number concepts in children provided an empirical basis for the course.

Professor Judah L. Schwartz, observing the proliferation of computers in the classroom and the poverty of disciplined examination of computers as educational tools or of the broader implications for the learning process, spent considerable time planning a course on "Introduction of Microcomputers in Education," for which he developed a categorical framework for classifying educational uses of the computer. The course, to be cross-listed at the Harvard Graduate School of Education, will review the present state of hardware and educational software; the application of the cognitive sciences to the design of games, tutorials, and simulations; the evolution of the roles of student and teacher and the likely organizational consequences of that evolution; and related subjects of interest to many members of the MIT community.

The third course is the consequence of several years of work by Professors Harold Abelson and Andrea A.-V. diSessa, who have been developing computer-based modules for teaching topics in freshman mathematics and physics -- in particular, vector analysis, Newtonian dynamics, orbital mechanics, geometric optics, and general relativity. Their research, described in greater detail in previous reports, has proceeded during the past academic year. With the cooperation of the Laboratory for Computer Science, and in consultation with representatives of the Departments of Physics and Mathematics, Professors Abelson and diSessa have refined the necessary software and will offer the course as an undergraduate seminar next term. It is appropriate to note here, as well, the publication by the MIT Press in the spring of 1981 of Abelson and diSessa's volume, Turtle Geometry.
The Division continued to sponsor weekly luncheon seminars, open to the MIT community, at which 26 MIT and outside speakers addressed a wide range of issues in psychology, cognition, mathematics, science, philosophy, and sociology, as they relate to education. About half of the speakers were members of the MIT community, including: Lotte L. Bailyn, Professor of Organizational Psychology and Management, and John T. Lynch, Engineer, Lincoln Laboratory; Jerome S. Bruner, Sloan Foundation Fellow, Harvard University and Visiting Professor of Psychology and Education; Carl Kaysen, David W. Skinner Professor of Political Economy, Program in Science, Technology, and Society; Kenneth Keniston, Andrew W. Mellon Professor of Human Development Program in Science, Technology, and Society; Martin H. Krieger, Visiting Assistant Professor, Department of Urban Studies and Planning; Peter Kugel, Computer Science Department, Boston College and Visiting Professor, DSRE; Jerome Y. Lottvin, Department of Biology and Department of Electrical Engineering and Computer Science; Francis M’Boule, Visiting Scientist, DSRE; Professor MacVicar, Cecil and Ida Green Professor of Physical Science and Education; James McCarthy, Resident Administrative Officer, Technology Adaptation Program, Cairo, Egypt; Seymour A. Papert, Professor of Mathematics and Education; Donald A. Schön, Ford Professor of Urban Studies and Education; Ruth Stavy, Israeli Ministry of Education, Tel Aviv University School of Education, Visiting Lecturer, DSRE; and Sylvia Weir, Research Associate, DSRE.

Distinguished guests provided the other half of the luncheon seminars: Paul J. Black, Director, Centre for Science Education at Chelsea College, University of London; Elise Bon-Rudin, Ed.D. Candidate, Graduate School of Education, Harvard University; Howard Gardner, Co-Director, Harvard Project Zero, Research Psychologist, Boston V.A. Hospital; Ernst von Glasersfeld, Professor of Psychology, University of Georgia; Andrew M. Gleason, Hollis Professor of Mathematics (sic) and Natural Philosophy, Head Tutor, Harvard University; Howard Gruber, Professor of Psychology, Director, Institute for Cognitive Studies, Rutgers University; Eileen Scanlon, Lecturer in Education Technology, the Open University; Bertrand Schwartz, University of Paris IX-Dauphine, Visiting Professor of Education and Engineering at DSRE and Center for Advanced Engineering Study; Hermina Sinclair de Zwart, Professor of Psycholinguistics, President of the Department of Psychology, School of Psychology, Université de Genève; Leo Treitler, Chairman of the Department of Music, State University of New York at Stony Brook; Martin Trow, Director, Center for Studies in Higher Education, Professor, Graduate School of Public Policy, University of California, Berkeley; Sing Tseng, Professor of Psychology, University at Shanghai; Daniel Wagner, Visiting Postdoctoral Fellow, Harvard University; Robert Wood, Visiting Professor of Political Science, Former Superintendent of Schools, Boston.

Attendance at the seminars continues to be high. The discussions following presentations are characteristically lively, yet the atmosphere remains informal. With the passage of time it has become increasingly evident that speakers have discovered that Division seminars provide an excellent, challenging format for testing hypotheses, particularly those that traverse traditional disciplinary boundaries, while listeners are eager for exposure to developments in fields which cut across their own research interests.

The DSRE working paper series, initiated two years ago with support from the Ford Foundation and edited by Professor Nelson, gathered momentum during the past 12 months. Six new papers were published, including Professor diSessa’s study of *Momentum Flow as an Alternative Perspective in Elementary Mechanics*; Professors Martin Rein and Sheldon White’s *Knowledge for Practice: the Study of Knowledge in Context for the Practice of Social Work*; Professor Schön’s *Intuitive Thinking? A Metaphor Underlying Some Ideas of Educational Reform*; Dr. Zwart’s *Hypothesis-construction in Children and Talking and Thinking*; and Dr. Weir’s report on her work with information prosthetics for the handicapped.

The Division values its ties with the Center for Cognitive Science. For the past year, Professor Daniel N. Osherson has been the most active intermediary between the two enterprises while Professor Susan Carey, also a member of the Center, has been on sabbatical. Professor Nelson continues her role as a member of the Center’s working group.

Finally, Division faculty served in advisory capacities in a number of national and international programs. Professor Schwartz continues to act as a consultant to the French government in the establishment of a new French national science museum. Professor Nelson fulfilled her responsibilities as a member of the study group on the National Institute of Education’s (NIE) research program on post-secondary education by participating in grant application review procedures. Professors Snyder and MacVicar served on the advisory committee of the Museum of Science in Boston.
ACADEMIC PROGRAM

Of the Division's offering of 22 graduate and undergraduate subjects, 14 were given during the past year, four jointly with other academic departments, and one with the Program in Science, Technology, and Society. One new course, Professor Richards' seminar on the "Construction of Mathematical Knowledge," has already been described.

Student enrollment remained steady at 73. In addition to course offerings, the faculty supervised 10 doctoral students enrolled in joint programs with the following departments: three with the Department of Urban Studies and Planning, two with the Department of Electrical Engineering and Computer Science, two with the Department of Psychology, and one each with the Departments of Mathematics, Mechanical Engineering, and the School of Architecture.

Three students received their Ph.D.s during the past year: Lucy Horwitz, jointly with the Department of Psychology, whose thesis title was "Solving Arithmetic Word Problems: The Role of Visualizability"; Ana H. Quintero, jointly with the Department of Mathematics, whose thesis was "The Role of Semantic Understanding in Solving Multiplication Word-Problems"; and Barbara White, jointly with the Department of Electrical Engineering and Computer Science, whose thesis was "The Design of Computer Microworlds that Facilitate the Understanding of Newtonian Mechanics."

The present Ph.D. program was strengthened by the introduction of a "core" course for DSRE graduate students, which ran during both the fall and spring terms. The course, which involved nearly all of the Division faculty, was designed to give graduate students broad exposure to research methodologies and individual perspectives represented in the Division. The program was divided into four- to six-week modules, each module conducted by a faculty team; students prepared original work for each module. The teaching faculty consisted of Professors Jeanne Bamberger, diSessa, Schön, Snyder, and Dr. Weir, with additional faculty as active participants in discussion. Conveners were, in the first semester, Professor Martin, and in the second, Professor Nelson.

RESEARCH PROGRAM

Members of the Division are engaged in a variety of long-term research efforts, most of which have been described in greater detail in previous reports. In the interest of conciseness, the long-range objectives of these programs will not be repeated here, but note must be made of specific investigations which have received funding during the past year, of significant developments within projects, and of new pieces of research which have been added.

The Division's sponsored research budget for the past year was $520,000. DSRE investigators received seven new grants and one contract renewal as follows.

Professor Papert received a grant from the National Science Foundation (NSF) and the NIE for a two-year project called "Interest Worlds: Mathematics in a Computer Culture," aimed at the development of computer-based "interest worlds" (writing, games, music, animated cartoons), through which children can encounter computation and the formal and mathematical concepts and operations embedded in it.

Professor Papert and Dr. Robert Lawler received a grant from the Spencer Foundation to extract publishable articles from a doctoral thesis that examined a child's cognitive development during several years' work in the LOGO computer environment. Professor Papert also continued his contract work with Texas Instruments to design personal microcomputers capable of running the LOGO computer language.

The NIE is sponsoring Professor Schwartz's and Dr. Quintero's study of "Intensive Quantity and Its Role in Solving Scaling and Estimation Problems," based on observation of children engaged in solving carefully formulated problems. The researchers will investigate the children's development of the concept of intensive magnitudes such as ratios, with particular emphasis on the transition from qualitative cognitive models to quantitative ones.
Professor Schwartz and Dr. Pearla Nesher have received NIE funding to support their study of "Methodology for Evaluating the Effectiveness of Schools," using existing statistical methods to analyze multi-year school performance data on 500 Israeli children, with a view to determining the feasibility of implementing such assessment procedures in US schools.

The Mattel Foundation is supporting Dr. Weir's investigation of motorically handicapped children through use of the LOGO computer environment. This study is aimed at determining the degree to which apparent intellectual deficits of such children -- specifically, the performance on spatial tasks of cerebral palsy children -- may be artifacts of standard testing procedures designed for normal children. The LOGO environment provides a set of tasks which are physically manageable for the children, while revealing their spatial reasoning styles. Dr. Weir has also received a grant from the Godfrey M. Hyams Trust to support other facets of her work with handicapped and learning disabled children.

Professor Bamberger's project in teacher development, in collaboration with the Cambridge Public Schools, has received continuing support from NIE. The current grant enables documentation and analysis of data gathered in the previous two years. With regard to long-range research initiatives, that segment of Professors diSessa's and Abelson's program devoted to the preparation of an undergraduate course in physics and mathematics has already been noted. They have also engaged in a year-long seminar focused on the construction of computer environments for undergraduates, a review of other computer-based educational materials, and work on a new computer language, "Boxer." The latter is being developed by Professors Abelson and diSessa as part of a larger project to develop an integrated computational environment for naive and novice users supported by an Army Research Program Administration (ARPA) grant through the Laboratory for Computer Science. In addition, Professor diSessa amplified his study of intuitive knowledge in physics through in-depth interviews structured to explore the unrefined knowledge of physics characteristic of novices, and trace its evolution into a formal knowledge of the subject during the process of college instruction.

Professor Snyder pursued his followup of the MIT Student Adaptation Study of the Class of 1965. During the past year, he made substantial progress in enlarging the data base for his longitudinal study by interviewing several more members of the Class of 1965, 16 years after their graduation, in their current work settings. The accumulation of this new set of interviews has illuminated Professor Snyder's understanding of the degree to which adaptive patterns and cognitive styles acquired during undergraduate years have opened certain sets of opportunities and foreclosed others.

Professor Schön completed the manuscript for his book tentatively entitled The Reflective Practitioner. It will be published by Basic Books, where the typescript currently awaits the printer.

The Work in Technology and Science (WITS) program directed by Edith Ruina, Research Associate in DSRE, published an information packet for junior and senior high school counselors and teachers to assist them in guiding their female students to careers in science and technology. The publication was supported by the American Physical Society.

PERSONNEL

Professor diSessa was promoted to associate professor this year. Professor Carey was on sabbatical, and Professor Papert took a leave of absence for research purposes.

The Division welcomed several long-term visitors during the year, including: Peter Kugel, Associate Professor of Computer Science, Boston College, was Visiting Associate Professor; Pearla Nesher, Senior Lecturer (Associate Professor), The Hebrew University and Head, Mathematical Education Division, Haifa University, was Visiting Associate Professor; and John Richards, Assistant Professor, Department of Philosophy, University of Georgia, was Visiting Assistant Professor.

Shorter-term visitors included the following: Jerome Bruner, Sloan Foundation Fellow, Harvard University, was Visiting Professor of Education and Psychology; Howard E. Gruber, Professor
and Director, Institute for Cognitive Studies, Rutgers University, was Visiting Professor; Harry Judge, Director, Department of Educational Studies, Oxford University, was Visiting Professor; Edwina Rissland, Assistant Professor of Computer Science, University of Massachusetts, Amherst, was Visiting Assistant Professor; Bertrand Schwartz, Professor of Sciences of Education, Université de Paris IX-Dauphine, was Visiting Professor of Education and Engineering; and Hermina Sinclair de Zwart, Professor of Psycholinguistics, University of Geneva, was Visiting Professor of Education and Developmental Psychology.

Professor Papert, a member of the DSRE faculty, received the Marconi International Fellowship.

BENSON R. SNYDER
BARBARA SCOTT NELSON

Educational Video Resources

Educational Video Resources (EVR) provides facilities, equipment, service, and advice to the MIT community on the educational, creative, scholarly, and research uses of video. It also acts as a contact point between MIT and the larger community on educational and cultural communications.

EVR has completed its second full year of operation. On the basis of experience, we can now characterize ourselves and the kinds of services we are called upon to provide. Following is a list of statements about our operations, with some illustrative examples and numerical figures.

Our professional production studio was in use an average of 15.4 hours per week, about 44 percent of the working hours at the Institute. The master control room, used not only for production but also for editing and tape duplication, operated an average of 89 hours per week. The small-format editing facility, where most users complete their three-quarter inch tapes, also operates day and night: an average of 111 hours per week over the year, and 138 hours per week during the peak months of December and April. The equipment library is also heavily used, with reservations for equipment sometimes required two weeks in advance. In addition to monitoring and assisting in these services, our staff participated in a number of productions, some of which are described below.

We are a major resource of the arts and media community at the Institute. Staff and students of the Film/Video Section used 43 percent of the time that our editing systems were engaged. Three of our seven color portable units are reserved for Film/Video classes during the term. Similarly, 25 percent of editing time was taken by fellows from the Center for Advanced Visual Studies. The Architecture Machine Group, the Visible Language Workshop, and the Creative Photography Laboratory used our facilities repeatedly.

Our users span the Institute. All 23 departments have used our services during the year, 13 of them more than six times each and five of them more than 20 times each. In addition, we have provided services to 31 laboratories and special programs, 18 student groups, and 13 administrative and service units of the Institute. There are 111 members of the MIT community who have "user cards," which means they have been trained and qualify to check out color portable cameras and recorders from the equipment library.

Many projects are ongoing. The major user of our professional production facility continues to be the Center for Advanced Engineering Studies, which taped approximately 100 lectures for their self-study series during the year. Much of the additional master control room use is the duplication of tapes for their customers around the world. We continued the practice of recording the introductory Physics 8.01 and 8.02 lectures and cablecasting them the evening before the following lecture. The class "Politics, Television, and the News" was shown live on the cable and taped for rebroadcast. We supplied the Department of Humanities with equipment and instruction to record and play back plays, lectures, and poetry readings. In our studio we recorded instructional videotapes for three Electrical Engineering classes and cablecast them repeatedly for student use. We recorded and cablecast various symposia (such as that on the MX missile) and lectures series (such as the Killian Lectures). Each week, two different noncopyrighted classic films were shown several times on the cable in cooperation with the University Film Study Center.
We tried some new uses of video during the year. In the spring semester we showed the weekly biology seminars on the cable, and, at the request of the Harvard Biological Laboratories, relayed the seminars to Harvard via the microwave link. The class, Digital Speech Processing, given in the summer of 1980 and the spring of 1981, was held in a special classroom in Building 9 with a live two-way cable video and audio link so that the professor and students in the classroom could observe the output of a computer in Building 36 and talk with a tutor-programmer there. We added eight commercial TV channels to the superband of the cable system, providing a good signal at any cable drop which has a converter. Our expectation is that these, plus the three MIT educational channels, will provide all of the Institute's television viewing needs. With help of interns from other Boston-area schools who produced programming and operated the cable headend, we increased the number of cable hours from 24 to 42 per week. We cooperated with the Industrial Liaison Program (ILP) in producing a 35-minute tape on fuel cells and catalysis, based on an ILP symposium, with inserted graphics and laboratory sequences. This tape will be distributed to industrial members to test the possibility of a self-supporting series of the same kind.

Video is pervasive in the public life of the Institute. The inauguration of Dr. Paul E. Gray as president was shown live on the cable and edited into archival programs. We continued our announcement program "Today at the Institute." Two video festivals ran on the cable system, one of works by members of the MIT community and one the nationally distributed Ithaca Video Festival. Each day, the CBS nightly news was taped and presented one-half hour later. Several current events resulted in large crowds around lobby monitors: the national presidential election, the assassination attempts on the Pope and the President of the United States, and the images of Saturn sent from Voyager I.

Increasingly we fulfill an advisory and consulting function. Departments, laboratories, and administrative units often approach us with a preliminary idea for the use of video and we help them plan the production, estimate the cost, and carry out the project. The Cambridge Multicultural Arts Center sought the advice of our staff on the technical design of a proposed production facility. Before meeting with a United States Congressman, Dr. Gray asked for background on low-power microwave educational broadcasting that may be curtailed as the result of a pending action by the the Federal Communications Commission (FCC).

We are responding to and leading educational and cultural communications developments in the community at large. Under a grant from the Alfred P. Sloan Foundation, we carried out during the past year a study of the relation between universities and local cable systems. After traveling around the country, employing a consultant, and studying the analogy of four Boston area university-based FM stations, we concluded that there was a need for a cooperative effort among educational and cultural organizations that span the Boston metropolitan area to inform one another about all the new communications technologies, to share resources, and to act as advocates to those who control the range of communications channels. After a series of meetings with other universities, state organizations, and cultural groups, we have founded the Metropolitan Educational and Cultural Communications Association (MECCA) with a director, Gisela Hoelcl, located initially in the EVR space at the Institute. The combination of educational and cultural organizations is unusual and grew naturally from the existing relationship between education and the arts at EVR. Over two hundred greater Boston organizations are potential members of MECCA, and would collectively represent a significant resource for educational and cultural planning, innovation, and programming nationwide.

Staff changes. During the year, John Speredelozzi, head of our maintenance operation, retired. Anthony J. Pastore, who has worked with Mr. Speredolozzi for a year and a half, took over the direction of maintenance, and Aldo Raucci came from Audio Visual Services to complete the maintenance staff.
Facilities Use

The Office of the Provost continues to formulate and implement policy for the use of Institute facilities by recognized MIT groups, guests from off campus, and by non-MIT organizations sponsored by faculty and recognized MIT groups. The Special Assistant to the Provost, Louis Menand III, is aided in these efforts by a committee comprised of Robert J. Holden, Associate Dean for Student Affairs; Carmen Besterman, Special Assistant in the Office of Chairman of the Corporation; Mary Morrissey, Director of the Information Center; Gayle M. Fitzgerald, Assistant for Special Events; and Winston E. Flynn, Assistant Registrar. Students from the Student Center Committee serve on this committee as well. The committee meets weekly to review facilities use requests.

Although use of MIT facilities is in part governed by the Institute's tax-exempt status, basically facilities use should contribute to the enhancement of purposes for which the Institute has been chartered, with primary focus on its educational and research roles. MIT facilities may not be used directly to support candidates for public office or for lobbying for particular legislative issues, nor may the Institute’s facilities be used to support profit-making organizations.

The domain over which this committee presides includes all of the academic space at the Institute, the Julius A. Stratton Student Center, departmental memorial rooms, and the like. Inevitably, this office and the Facilities Use Committee are drawn into broader issues involving controversial and difficult potential uses of MIT facilities. As a consequence, the Office of the Provost is frequently consulted on a wide range of political, social, and even religious issues stemming from facilities use. For example, the appropriateness of activities suggested for the Independent Activities Period (IAP) in January of each year is reviewed by the Special Assistant to the Provost who frequently consults the Committee as well as other appropriate offices within the Institute.

During the 1980-81 year, in addition to a number of smaller meetings, MIT hosted the Seventh International Conference on Atomic Physics, the Annual Meeting of the International Committee on Thrombosis and Haemostasis, the Annual Conference of the American Physical Society, the Massachusetts Public Health Association Conference, the Conference on the Techniques for the Characterization of Composite Materials, and a campus visit in association with the Centennial Convention of the American Association of University Women. The presentation by undergraduates of talks by candidates for public office is considered to be educational in nature, and therefore provision is made for the appearance of candidates for a variety of public offices.

LOUIS MENAND III

Harvard-MIT Division of Health Sciences and Technology

Planning for the future evolution of the Harvard-MIT Division of Health Sciences and Technology (HST) is being carried out in the context of the establishment and development of the Whitaker College at MIT, and of the developments which are occurring at Harvard, especially in the Faculty of Medicine. The Division is afforded the challenging opportunity of promoting harmonious and productive interaction of its educational and research programs with related activities in the two universities.

During the past year, the Administrative Council heard reports on: the Center for Health Effects of Fossil Fuel Utilization, presented by Professors Gerald N. Wogan, William G. Thilly, John P. Longwell, and Frank E. Speizer; the Neurosciences at Harvard University, presented by Professor Torsten N. Wiesel; plans for the new Department of Social Medicine at Harvard Medical School, by Professor Leon Eisenberg; and plans for the Harvard University Division of Health Policy, by Professor David Hamburg.
The Joint Faculty Committee approved the recommendation of Professor Farish Jenkins that a search be conducted for a faculty member at non-tenure level as a primary HST appointment. This search is currently in progress. The Committee was addressed by Professor G. Octo Barnett on the use of computers in medical education, and recommended that a subgroup of the Curriculum Committee consider how best to incorporate computer science in the HST educational programs. This study is now underway. Considerable discussion by the Joint Faculty Committee was devoted to the option of the M.D. degree for Medical Engineering and Medical Physics Ph.D. candidates, which is described below.

The Biomedical Sciences Curriculum

The question is often asked whether HST students constitute a group which can be distinguished from students in the regular curriculum of Harvard Medical School. The strong research and academic interests of HST students are reflected in their pursuit of combined M.D.-Ph.D. degrees and in the honors in special fields which they are awarded upon graduation. Although HST students constitute 15 percent of the total student body, they constitute a majority of M.D.-Ph.D. candidates, and in 1980-81, they received 60 percent of the honors in a special field.

During the past year, HST-141 Molecular Basis of Clinical Disorders, taught by Professors Paul M. Gallop and Irving M. London, was modified by the addition of an outstanding series of lectures by Professor Nancy Hopkins and Professor Phillip Sharp of the Department of Biology. This lecture series was concerned with the molecular genetics and molecular biology of eukaryotic cells. We intend to make this lecture series a regular feature of HST-141, and to incorporate lectures on human genetics by Professor Samuel Latt in the further evolution of this course.

In accordance with the now well-established procedure of detailed reviews of each of the HST courses, analyses and critiques of several courses were carried out during this past year. The reviews have proved extremely valuable and constructive in the evolution of these courses. In the reviews, knowledgeable faculty members, who are themselves not engaged in teaching these courses, and students, who have directly participated in the courses, are involved in the analysis and critique. The principal faculty members responsible for the courses have a full opportunity to hear the critique, to answer questions, and to benefit from the suggestions which are made in a responsible and constructive fashion.

For example, HST-200 Introduction to Clinical Medicine was reviewed specifically from the standpoint of the desirability of continuing it as an HST offering at the Brigham and Women's Hospital. The review was conducted in response to a request by a senior faculty member that HST students be mingled with the other Harvard medical students in Introduction to Clinical Medicine as well as in the principal clinical clerkships. An HST faculty-student committee, a subcommittee of the Curriculum Committee, performed the review and concluded that the course presented at the Brigham and Women's Hospital by Drs. W. Hallowell Churchill and James E. Pennington is excellent, has features of particular interest to HST students, and should be maintained as an HST offering primarily.

In the discussions of the Curriculum Committee, a point repeatedly raised has been the need for advanced courses in pathologic physiology. This has relevance particularly to the fourth year in the medical curriculum, which is often less productive than it could be. The development of advanced pathophysiology courses would have the distinct advantage of offering a deeper understanding in the areas of special interest to students, and would relate well to the system of concentration in which HST students participate.

Another suggestion which may be pursued is the development of a research seminar for fourth-year students. HST students, all of whom write a thesis based on their own research, might benefit from the opportunity of presenting their research findings to their peers. A seminar would afford them an opportunity to learn about the research activities of other students and to describe their own work.

During the past year, special efforts were made to increase the recruitment of women and minority students. These efforts included the sending of student and faculty members to major institutions from which well-qualified candidates might come, and the sending of descriptive literature about HST to premedical advisors in major colleges and universities.
Medical Engineering and Medical Physics

During the academic year 1980-81, the Medical Engineering/Medical Physics (MEMP) program added two new clinical experiences to its curriculum, one in anesthesia and the other in orthopaedics. The clinical experience in anesthesia is conducted at the Massachusetts General Hospital under the direction of Drs. Edwin Trautman and Richard Kitz. The clinical experience in orthopaedics is conducted at the Beth Israel Hospital under the direction of Drs. Wilson C. Hayes and Augustus A. White.

The MEMP curriculum underwent extensive review by faculty and students, who concluded that the original curriculum required the students to complete more work during the first two years than was practical. The extensive core requirements in the biomedical sciences made it very difficult for students to incorporate appropriate work in the engineering sciences. Furthermore, there was need for additional subject offerings in medical engineering.

Alternative solutions were considered: an increase in the preclinical period to three years or to two and one-half years. The latter alternative was selected with the additional suggestion that one biomedical science requirement, HST-060 Endocrinology, be dropped and that an additional medical engineering subject, HST-582 Biomedical Signal Processing, be added. This arrangement, which requires a shift of HST-201 Introduction to Clinical Medicine to the spring term, provides students with an additional semester to complete the writing of the S.M. thesis, and to complete the doctoral qualifying examinations. This new curriculum will be voted on by the faculty in the fall of 1981.

During the spring term, the Faculty Council of the Harvard Medical School voted to admit up to three students from the MEMP program as students with advanced standing. The proposal, approved by the Curriculum Committee of the Harvard Medical School, calls for MEMP students to apply to the Medical School in the year preceding their clinical year. Students admitted with advanced standing would combine clinical experiences of the two curricula, i.e. the Introduction to Clinical Medicine, Surgery, and one additional clinical elective in the MEMP program, while the remaining required clinical experiences, including Medicine, would be completed in the biomedical sciences curriculum. All preclinical requirements for the M.D. degree would be met as well.

In the spring, the Division participated in a thorough review of the status of medical engineering at the Massachusetts General Hospital (MGH). This review was conducted by Professor Ernest G. Cravalho, associate director for MEMP of HST; Dr. Richard J. Johns, head, Department of Biomedical Engineering, Johns Hopkins University; and Dr. Murray Eden, chief, Biomedical Engineering Division, National Institutes of Health (NIH). They recommended that 1) MGH, with the aid of HST, should establish an academic department of medical engineering which would be accorded the same recognition and status of other academic departments in the hospital; 2) the department, which would have teaching, research, and clinical service responsibilities, would be headed by a faculty member holding an endowed chair in HST; and 3) MGH should provide sufficient space and fiscal resources to support the various components of the department. These recommendations are to be considered further by HST, the MGH administration, the faculty of MIT, and the Harvard Faculty of Medicine.

Ten new students were admitted to the MEMP program for fall 1981. Dr. Jonathan W. Valvano completed the program requirements in July 1981 and will begin work as assistant professor of biomedical engineering at the University of Texas, Austin, in September 1981.

Dr. James C. Weaver of HST developed a new research program with Ortho Diagnostics, Inc., a division of the Johnson & Johnson Corporation. This research is directed at the development of new techniques of fluorescent cell sorting using gel droplets and has potential applications in biotechnology.

One staff change occurred this past year. Professor Walter Olson left the HST Faculty in November 1980 to join the Medtronic Corporation. His teaching duties in HST-580 were assumed by Dr. James Weaver, in HST-581 by Dr. Edwin Trautman, and in the clinical experience in cardiology by Dr. Dan Adam. A search conducted for a permanent replacement for Professor Olson identified Professor David Edell of the University of California, Davis, as the outstanding candidate for this position. Professor Edell, who is an expert in the design and fabrication of implantable integrated circuits for the measurement of physiological parameters, will hold a joint appointment in
HST and the MIT Department of Electrical Engineering and Computer Science. He will join the faculty in September 1981 and will assume responsibility for new research initiatives in integrated circuit design and fabrication and for teaching in the general area of biomedical instrumentation.

RESEARCH ACTIVITIES

Research and development activities in HST engage multidisciplinary groups of scientists, engineers, and physicians directing their efforts to the solution of important medical and health problems. Seventy research and development projects are currently in progress in three major centers, in four broad research programs, or as individual research efforts. More than 80 MIT and Harvard faculty and senior research staff members are involved in HST research.

Centers

The Biomedical Engineering Center for Clinical Instrumentation, under the direction of Professor Roger G. Mark, performs basic research in engineering science and development of new clinical instrumentation primarily based on microprocessor technology. Projects currently underway include cardiac arrhythmia analysis with a patient-carried computer, a vestibular testing system for neurologic disorders, measurement of the thermal properties of tissue, basic transduction processes in assessing single cells and microorganisms and microstructures, and integrated electrode and signal processing arrays. In addition, there is a program of research in cardiac electrophysiology. Three projects involve industrial collaboration in an effort to facilitate technology transfer.

The Rehabilitation Engineering Center (REC) is a collaborative effort of MIT and Children's Hospital Medical Center devoted to the application of engineering science and technology to the problems of the physically handicapped. The REC projects, under overall direction of Dr. William Berenberg, Professor Robert W. Mann, Dr. Melvin Glimcher, and Dr. John Hall span the range of activity from bioengineering research to clinical evaluation with emphasis on neuro-muscular control and sensory feedback. Projects include microprocessor-based systems for non-vocal communication by the severely handicapped, innovative bracing systems for correction of orthopaedic deformities of the spine and legs, tactile and auditory information displays for the blind, and a clinical auditory biofeedback for muscle reeducation.

Center for Health Effects of Fossil Fuels Utilization. This Center, and an associated research program for study of potential health effects of combustion products of fossil fuels, has been established under HST and the MIT Energy Laboratory. Key objectives of the research, directed by Professors Wogan and Jean F. Louis are to develop a data base with which to assess potentially mutagenic and/or carcinogenic products from fossil fuels combustion, and to identify alternative combustion methods and fuel utilization strategies that could reduce health hazards. To accomplish these goals, closely integrated research efforts involving combustion engineers, physicists, chemists, biologists, and toxicologists have been undertaken.

Broad Research Programs

The Thromboresistant Materials Program has as its goals the design and development of thromboresistant materials and the exploration of basic aspects of interaction of blood with artificial surfaces. The collaborating investigators are Dr. Edwin W. Salzman, and Professors Edward W. Merrill and David F. Waugh.

The program on Optimization of Dose Distribution in Cancer Radiation Therapy seeks to incorporate advanced engineering and computer technology into radiation therapy with the goal of delivering increased doses of radiation precisely to a tumor site with minimal injury to normal tissue. The interdependent research projects, under overall direction of Dr. Bengt E. Bjarngard, are in the areas of radiation treatment planning, radiation treatment delivery, and clinical evaluation of computer-controlled radiation therapy.

The objectives of the Short-Lived Radiopharmaceuticals for the Diagnosis and Treatment of Disease program, under the direction of Dr. S. James Adelstein and Professor Gordon L. Brownell, are
improvements in clinical nuclear medicine through design and development of radiopharmaceuticals that lead to greater specificity, reduced dosage, and enhanced diagnostic imaging quality.

Individual projects include: the development of a radioactivity detection system for screening patients for coronary artery disease; determining the mechanisms by which double-stranded RNA regulates protein synthesis; elucidation of the mechanisms controlling the synthesis of hemoglobin and other proteins in animal cells; and the development of new methods to characterize reactive species in radiopharmaceuticals using high pressure liquid chromatography and field desorption mass spectrometry.

Several new research projects have been initiated during this past academic year: they include studies on cataract formation, eye convergence, the effects of long-term exposure to diesel railroad engine exhaust, and the analysis of radiopharmaceuticals.

IRVING M. LONDON

Whitaker College of Health Sciences, Technology, and Management

The new Whitaker College building is scheduled for occupancy in the fall of 1981. In addition to its teaching classrooms and research laboratories, this new facility will provide central facilities for tissue culture, scanning and transmission microscopy, computation services, instrument design and development, animal care and experimentation, a library, and office space for the faculty, staff, and students of both Whitaker College and the Harvard-MIT Division of Health Sciences and Technology. The building, which is located adjacent to the Cancer Research Center on the east campus, provides approximately 82,000 net square feet of space. During the past year, programmatic activities have developed in the areas of human biology and experimental medicine, in medical engineering and medical physics, and in health policy and management.

In the human biology/experimental medicine area two faculty appointments were made of experts in atherogenesis and thrombosis research. Professors Robert D. Rosenberg and Monty Krieger are each joint faculty members in the Whitaker College and in the Department of Biology, and will initiate research and teaching programs which complement existing strengths in MIT and help develop new areas. Three additional search committees are in operation with focus on the neurosciences, on human genetics, and on parasitic diseases, respectively.

In September 1980, Professor Alan C. Nelson, a biophysicist from the University of California at Berkeley, joined the faculty. He holds a joint appointment with the Department of Nuclear Engineering and the Harvard-MIT Division of Health Sciences and Technology (HST), and will have responsibility for directing the activities of the electron microscope facility of the Whitaker College. He is aided in this process by a faculty steering committee with membership drawn from the Departments of Physics and Biology and the School of Engineering. This facility will provide not only the electron microscope and specialized light microscope services necessary for the research efforts of the College, but will also engage in fundamental research in the technology of electron microscopy.

On July 1, 1981, Professor Robert Langer, presently of the Nutrition and Food Science Department, will join the Whitaker College to assume responsibility for developing teaching and research initiatives involving the application of chemical engineering science to medicine and biology. Initial work will be focused on research in drug delivery systems and in the kinetics of drug metabolism.

Under the leadership of Dr. Nelson Kiang of the Eaton-Peabody Laboratory, a group of faculty members has formulated a new program in the communicative sciences. This program, which draws primarily on the present strengths of the Electrical Engineering and Computer Science Department, includes both teaching and research components. The Whitaker College will provide some of the resources required for this program and will serve as the administrative entity to coordinate the efforts of faculty in various departments. The proposed program has been presented to the Provost for review.
Exploration of teaching and research opportunities in cardiac electrophysiology continues. A faculty committee has been meeting with leading experts in the field from various institutions. The committee expects to propose a formal plan during the 1981-82 academic year.

Plans have been formulated to include in the new building an animal physiology research laboratory that would provide much-needed animal research space for faculty in the School of Engineering. This space would enable investigators to set up equipment and instrumentation for experimental purposes on a longer term basis than is presently possible in animal surgical sites located in other parts of the campus.

In health policy and management, a major grant was awarded by the Henry J. Kaiser Family Foundation for establishment of an interdisciplinary doctoral program. The Foundation has provided the full five-year grant of $1.5 million in a lump sum, thereby increasing the effective funds available during the period of the grant. The grant will be used for curriculum development and implementation of a new proposed Ph.D. program in health policy and management, with strong ties to several cooperating MIT departments; development of a related new Laboratory for Health Care Studies; fostering basic and applied research activities that are critical to the success of both the Ph.D. program and the new laboratory; and financial support of meritorious predoctoral students and other qualified visiting scholars. The program will be conducted by the Whitaker College Health Policy and Management Group, with the support of the MIT Medical Department and Health Plan, the Harvard-MIT Program in Medical Engineering and Medical Physics, the Alfred P. Sloan School of Management, and the Departments of Economics, Political Science, and Urban Studies and Planning. The executive committee consists of Edward B. Roberts, David Sarnoff Professor of Management in the Sloan School of Management, chairman; Dr. John F. Rockart, director of the Center for Information Systems Research; Harvey M. Sapolsky, professor of political science; Peter Temin, professor of economics; and Christopher T. Walsh, the Uncas and Helen Whitaker Professor and associate director of the Whitaker College, and professor of chemistry and biology.

In addition to the Kaiser grant for health policy and management, the Whitaker College has received $50,000 per year for five years from Johnson & Johnson for support of postdoctoral fellows in experimental medicine or medical engineering. Two other major gifts were made during 1980. Mrs. Helen Whitaker established the Uncas and Helen Whitaker Professorship as the first endowed chair in the Whitaker College. Professor Walsh, professor of chemistry and biology and associate director of the Whitaker College, was named as the first recipient. A $1 million grant has been given by the Pew Memorial Trust for outfitting and equipping the new Whitaker College Building.

Keiko F. Oh has been appointed as administrative officer and Mr. Edward J. Gaudiano as facilities officer in the Whitaker College.

IRVING M. LONDON

Independent Activities Period

In its eleventh year, the Independent Activities Period (IAP) has become an important and accepted part of the Institute's academic year, according to a report presented to the faculty this past April by the IAP Policy Committee. Responsible for reporting on the health of IAP every four years, the IAP Policy Committee, with the help of the IAP Administrative Committee, monitors IAP and collects various kinds of data on a yearly basis. In preparation for this report, the committees also conducted more than 60 interviews with department heads, faculty members, and students, with the aim of characterizing what people do during IAP and determining whether or not they find IAP valuable.
During IAP, most students are on campus and are involved in a wide range of academic and non-academic projects of their own choosing. Kristin K. Foss and Michael E. Schlein, student members of the IAP Administrative Committee, visited various living groups during January 1981 and reported finding

...students taking classes at Harvard, brushing up on foreign languages, building a 12-foot bar at Baker House, skiing, finishing 18.02C, growing beards, reading, traveling, finishing incompletes, sleeping, looking for summer jobs, making quilts, working full-time, practicing with musical instruments, using the new athletic facilities, learning to be bartenders, attending a Beatles' festival, or just plain vegetating. Varsity teams went on competition tours, and students attended various lecture tours on and off the MIT campus.

In their interviews, students said they also use IAP to earn money for tuition, and they repeatedly emphasized the importance of IAP as a time to concentrate on Undergraduate Research Opportunity Program (UROP) projects.

Based on interviews with faculty members and department heads, the IAP Policy Committee concluded that

...faculty value IAP as a time to catch up on research and proposal writing, to concentrate on articles or books in progress, to carry on outside professional activities, or to prepare for spring term classes. Although faculty members are freed from the demands of classroom teaching, many of them work as intensively as ever during IAP.

Faculty opinions about IAP range, as they have since the program's inception, from "It is the best thing that happens here," to "It should be abolished." The latter sentiment remains in the minority. Almost all faculty members interviewed noted that their contacts with students involved in research -- whether thesis or UROP students -- intensify and improve.

Faculty, student, and staff volunteers throughout the Institute continue to offer more than 500 specially organized activities which are listed in the IAP Guides. According to activity leaders, attendance remains high at these activities, which, this past year, ranged from a workshop to recreate models of Leonardo da Vinci's inventions, to lecture and laboratory sessions on algae, to a lecture-demonstration on cuisine chemistry. This public side of IAP retains its vitality through the continued strong interest of students and the increasing participation of staff.

However, the IAP Policy Committee reported that faculty members are not participating in IAP activities in such large numbers as they did in the past. In 1974 about one-third of the faculty was listed in the Guide; this past IAP only slightly more than one-fifth was listed. Some of the largest departments offer only a few activities, and their department heads explain that faculty must use IAP to recover from being overcommitted during the term. The IAP Policy Committee commented that

...since IAP has become an established part of the calendar, it has lost the element of spontaneity and surprise that once made faculty members see it as a chance to do something different. For many it has now become a regularly scheduled period to catch up on year-round non-teaching activities. Released from the demands of regular classes but intensifying their work with research students, many faculty members feel little responsibility to increase contact with students in informal and creative ways.

The IAP Policy Committee recommended that the faculty look at the issue of faculty and departmental responsibilities in light of existing practices, and either reaffirm or revise existing policies. Because the issue of faculty pace extends beyond IAP, the Committee suggested that the Committee on Educational Policy (CEP) discuss the problems of declining faculty participation in IAP activities in the context of faculty commitments for the entire academic year.

For the past four years the IAP Policy Committee has been chaired by Woodie C. Flowers, associate professor of mechanical engineering, who resigned from the Committee at the end of this past academic year. IAP has benefited from his leadership, and on behalf of all of us who are involved in the administration of IAP, I thank him for all the work he has done. Other members of the 1980–81 IAP Policy Committee were Nick B. Adams; Professors Edward B. Allen, Catherine V. Chvany, Ernest G. Cravalho; Mary Z. Enterline (staff); Christos Georgakis; Professor Kenneth
Hale; Dr. Merton J. Kahne; Professors Henry W. Kendall, Harvey F. Lodish; Dr. Louis Menand III; Professors David Michael, Robert O. Ritchie, Robert J. Silbey, J. Edward Vivian, Eric A. von Hippel, and Rainer Weiss. The chairmanship of the IAP Policy Committee will now be held by Daniel S. Kemp, professor of chemistry.

The 1980-81 IAP Administrative Committee included Margaret S. Richardson (chairperson), Elizabeth C. Bradley, Ms. Enterline, Ms. Foss, Edward J. Gaudiano, Patricia Joffee, Trond Kaaslstad, Donna Lee Kennedy, Howard A. Marson, Dr. Menand, Rosemary B. Mone, Angela M. Price, Lawrence W. Ryan, Jr., Michael E. Schlein, Clifford A. Truesdell, and Maryglen Vincens. Dr. Menand, Special Assistant to the Provost, chairs the IAP Planning Committee, of which the members are departmental coordinators. Operations for IAP are supervised by Ms. Enterline, manager of IAP and the MIT-Wellesley Exchange. This past August three new staff members joined the IAP Office. They were Ms. Vincens, staff editor/writer, Ms. Kennedy, coordinator, and Ms. Price, senior office assistant. Ms. Kennedy left the office at the end of the academic year.

MARY Z. ENTERLINE

Information Processing Services

Some of the most significant changes in the operations of Information Processing Services (IPS) during fiscal year 1981 occurred in the areas of management structure and reporting responsibility. Effective July 1, 1980, IPS began reporting to the new director of Computing and Telecommunications Resources, Professor Fernando J. Corbató, who reports to the Provost, Professor Francis E. Low. Our prior reporting structure had been to the Office of the Chancellor which was abolished when Chancellor Paul E. Gray became President of the Institute. This new structure follows closely the recommendations put forth in the March 1979 report of the Ad Hoc Committee on Future Computational Needs and Resources, chaired by Professor Michael L. Dertouzos and Weston J. Burner. In addition, this report also recommended the establishment of a committee of faculty and staff to oversee and direct MIT's computing plans. This committee, the Ad Hoc Committee on the Computing Environment, also has been established and is chaired by Professor Robert I. Hulsizer, Jr.

In the administrative computing area two major organizational changes have occurred. First, a committee comprised of the vice presidents representing the major administrative information system areas has been established and is called the Administrative Information Systems Steering Committee. Headed by William R. Dickson, this group monitors the progress of computerized information systems projects, sets priorities on the selection of new projects, and acts as a communications vehicle for MIT's senior administrative officers and IPS's centralized information system activities.

The second major administrative change was a result of the EDUCOM study of MIT's administrative information systems which was made late last spring. One of the principal suggestions made by this consulting team was that MIT establish and fill the position of associate director of IPS with the responsibility of directing the new systems development and the production of MIT's administrative processing. We began this process about mid-year with a search committee made up of Professor Fernando J. Corbató, Philip J. Keohan, James J. Culliton, William J. Hecht, and Weston J. Burner, chairman.

The committee reviewed resumes from both internal and external candidates and in the final process, selected and appointed Jean C. Bonney. Mrs. Bonney had supervised the academic and research computing services operation at IPS for the past four years.

The following items summarize the operational highlights of IPS during fiscal year 1981.
Academic and Research Computing

Efforts put forth during the year to enhance our technical support to the statistical and numerical computing community have resulted in significantly better user relations. Because of this effort, we have been able to establish an interdisciplinary user forum on statistical computing, and have experienced increased demand for technical consulting in the early planning process from researchers deciding which application software packages and which statistical methods would be most appropriate for their particular process. This has been a very satisfying experience for our numerical and statistical analysts.

We continue to teach a number of non-credit courses, ranging from simple, introductory, survey-type courses on computing at IPS to courses in advanced programming techniques. Courses are offered by IPS during three periods in the year: early fall, the Independent Activities Period, and early summer.

The east campus computing facility at the Sloan School of Management has achieved an outstanding level of satisfaction between the remotely located IPS staff, the management of the Sloan School, and the east campus user community. Much of this success has been the result of staff effort on the part of those located in that area.

IPS has always taken pride in the quality and quantity of its user documentation and maintains a complement of publications for its users which is equal to or better than that of any other university computer center. During 1981, we produced or significantly revised 35 of these publications, including a new IPS *Quick Guide to Computing*, a Multics primer, a Multics word processing GUIDE, and a manual of CMS at IPS. Publication rights to this latter document, because of its quality, have been acquired by other universities and commercial organizations.

During 1981, IPS, in conjunction with the New England Regional Computing Program (NERCOMP) and the Harvard University Computing Center, initiated a joint project to support and encourage use of the 1980 United States Census materials and the software package CENSPAC, provided by the Census Bureau. In this effort, a full-time member of NERCOMP shares her time between Harvard and MIT, acquiring census data, producing user documentation, assuring software data access packages, conducting seminars, and consulting with users. Through this activity, it is planned to provide not only full-service consulting on census materials, but a reasonable complement of the database itself at Harvard and MIT. In addition, a regional resource now will be available to other New England colleges. Cost of the activity is shared among Harvard, MIT, and NERCOMP member colleges.

With the advent of microcomputers, both on and off the campus, IPS, during 1981, established a microcomputer consulting unit where community members can evaluate microcomputer alternatives, attend seminars on programming micros, and, in general, obtain answers to questions on hardware, software, and the feasibility of applications.

Administrative Data Processing

During 1981, our backlog of outstanding tasks for modifications to existing systems was reduced significantly. We began the year with 90 requests, added 92 more during the year, and completed 130, leaving a balance of 52. This is the smallest backlog we have been able to attain for the past six years. Reasons for this are probably twofold. First, all programming is now done using computer terminals attached to the IBM 370/168 and 148, using the timesharing system CMS. This has significantly improved programming efficiency and productivity. Secondly, two major systems, which in the past have contributed heavily to the modification and maintenance backlog, are now in the new systems development stage which has all but eliminated requests for changes in the existing applications. These two systems are Payroll and Alumni/Gifts.

From a production standpoint, we continue to run with a high level of performance. During 1981, we scheduled 11,830 jobs and completed 11,463 on time as originally scheduled, for an average of 97 percent.

Hardware enhancements to administrative users included increased use of the Xerox Model 1200 printer in Building 39 through a remote network connection between the IBM 370/148 and the IBM 370/168. Users seem much happier with the 8½x11 inch output rather than with the traditional
11x14½ inch computer paper. Delivery of output from one building to another has not slowed down the receipt of the product by the end-user, primarily because of scheduled courier runs and the increased speed of the Xerographic printing versus the conventional impact printing method. In addition, there has been a continued expansion in the use of ADABAS software; a network of 30 remote terminals in administrative departments now access the Alumni/Gifts; Financial, and Payroll data bases.

In new systems development, we continued to exploit ADABAS on our four major systems efforts, Payroll, Alumni/Gifts, Budgets, and Admissions. As planned, the 1982-83 Admission's cycle will be totally an on-line application. The Alumni/Gift system also will be cut over for full production in the September/October timeframe. In the area of Payroll, all basic paying functions have been programmed and are undergoing audit and test. Conversion of payrolls to the on-line system will proceed during the 1982 fiscal year.

With some of these major efforts now drawing to a close, the Administrative Information Systems Steering Committee has determined that new systems will now be developed in Pension Accounting and in Personnel. Both are closely related to the Payroll applications and will be developed using the database management software ADABAS. Completion is scheduled for July 1, 1982.

Computer Operations

Major systems now serving the academic, research, and administrative communities include an IBM 370/168, 370/148, 4341, 4331, and a Honeywell Level 68/DPS. The Honeywell equipment and the IBM 4341 were installed this year. The Level 68 replaced our previous Model H6180, and the IBM system was installed to run the new administrative systems, utilizing the ADABAS software.

In addition, during 1981, we also installed an IBM 6670 laser printer for text and word processing output; additional IBM 3270s and Digital Equipment VT100 full-screen terminals for public usage; and a Nicolet/Zeta Model 3600, four pen, high-speed plotter.

From a usage standpoint, we have seen 100 simultaneous interactive users on Honeywell Multics system and 150 on-line on the IBM 370/168. In addition, the Xerox 1200 printer now delivers 800,000 pages per month on the average.

Considerable effort was expended during the year to improve our terminal access to end-users and network our installed mainframes to permit not only the sharing of peripherals and databases but also to provide sufficient redundancy in hardware and software to provide processor backup for critical applications in case of emergency.

Systems Programming

Our continued software test site arrangement with Honeywell’s Cambridge Information Systems Laboratory included the installation of 18 versions of the Multics operating system and 267 logical modifications and changes. In addition, we have developed a network gateway processor facility on Multics so that users may access both the Tymnet and Telenet value added commercial networks directly from the Honeywell Level 68/DPS hardware. This gateway was implemented using a Digital Equipment Model LSI/23 processor.

Our experience using ADABAS software and the Software ag supplied teleprocessing monitor COMPLETE showed we were encountering significant performance problems which manifested themselves in intolerable terminal responses for the end-users. Working closely with Software ag, we have converted most applications and usages to the IBM Conversational Monitoring System (CMS) and this project will be complete by early 1982. Significant improvement in performance and user satisfaction have resulted because of this effort.

Terminal users using the standard asynchronous ASCII terminal access to our IBM 370/168 will soon be able to gain the advantage of full-screen support normally available only from binary synchronous Model 3270 devices because we have acquired an IBM Series 1 minicomputer which will interface directly into the Model 370/168 channel and simulate the binary synchronous protocol. It is expected that the hardware and software will be available by September 1981.
IPS currently operates with approximately 165 equivalent full-time employees and a total headcount, considering part-time employees, of 174.

As always, turnover of our staff is a significant problem because of the continued high demand for experienced computer personnel within the Boston area. Our turnover rate was more than 20 percent. In spite of this, our affirmative action goals have been very close to being met.

Statistics are as follows:

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<tr>
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<th>1981 Actual</th>
<th>1981 Goal</th>
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<td>Number of Employees</td>
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<td>36%</td>
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<tr>
<td>Number of Minorities</td>
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<tr>
<td>Percent of Minorities</td>
<td>13%</td>
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WESTON J. BURNER
JOSEPH R. STEINBERG

Laboratory for Computer Science

The Laboratory for Computer Science (LCS) is an MIT interdepartmental laboratory whose principal goal is research in computer science and engineering.

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

The first such area, 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 carried out by the Clinical Decision-Making Research group; the use of mathematical knowledge by the Mathlab Research group for an automated "mathematical assistant"; the use of knowledge in programs that comprehend typed natural-language (English) queries; and the use of specific knowledge about budget for a budget planning system.

Research in the second and largest 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 distributed operating systems and the architecture of single-user powerful computers that are interconnected by communication networks. Communication networks for such distributed environments are pursued by the Computer Systems and Communications group, while distributed file servers and cryptographic protection techniques are pursued by the Computer Systems Structures group. Other research in this area includes the architecture of very fast multiprocessor machines by the Computation Structures and Functional Languages and Architectures research groups, and the use of networks to link large numbers of computers engaged in computationally intensive tasks.

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
Laboratory for Computer Science

group strives to understand ultimate limits in space and time associated with various classes of algorithms, the semantics of programming languages from both analytical and synthetic viewpoints, the logic of programs, and the links between mathematics and the privacy/authentication of computer to computer messages.

The fourth area of Laboratory research, entitled Computers and People, entails societal as well as technical aspects of the interrelationships between people and machines. Examples of research in this area include office automation research carried out by the similarly named laboratory research group, the use of interconnected computers for planning, as well as the sociological impact of computers on individuals, and the ethical problems of distributed responsibility posed by multiprogrammer systems.

During the past year, the Laboratory consisted of 279 members -- 39 faculty, 20 visitors and visiting faculty, 74 professional and support staff, 102 graduate and 44 undergraduate students -- organized into 17 research groups. The academic affiliation of most of the faculty and students is with the Department of Electrical Engineering and Computer Science. Other academic units represented in the Laboratory membership are the Departments of Mathematics, Architecture, and Humanities; the Division for Study and Research in Education; and the Sloan School of Management. Laboratory research during 1980-81 was funded by 16 governmental and industrial organizations, of which the Defense Advanced Research Projects Agency (DARPA) of the Department of Defense provided about half of the total research funds.

The 1980-81 year was very active. Technical results were disseminated through the publications of the Laboratory members and will not be discussed here. The following items are the highlights of the year.

The rapid growth and changing nature of the computer field were felt during the 1980-81 reporting period through the creation of four new research groups. Two of these groups resulted from "mitosis" of the Laboratory's oldest group (Computer Systems Research), which pioneered many of the important early time-sharing results of Project MAC (now the Laboratory for Computer Science). The first of these new groups, entitled Computer Systems and Communications (CSC), is led by Professor Jerome H. Saltzer and includes Principal Research Scientist Dr. David D. Clark in its leadership. This group investigates computer systems problems that arise in making effective use of new communications technology. Current research topics include: gaining field experience with ring networks; the solution of technical problems encountered in building and managing a campus-wide network of several thousand computers; investigation of methods for producing high-quality, high-performance implementations of network protocols; and investigation of feasibility of a pocket communications terminal.

The second new research group is entitled Computer Systems Structures (CSS), and is led by Professor David P. Reed. The group's goal is the study and synthesis of system building blocks that support distributed applications. A principal block currently under construction is a distributed data storage system called SWALLOW. In addition, projects are under way in the areas of (a) debugging and monitoring distributed systems; (b) intermodule naming and linking in distributed systems; and (c) authentication in distributed systems.

The Educational Computing group (EC), the third new Laboratory group established in 1980-81, is under the leadership of Professor Harold Abelson with Professors Andrea A-V. diSessa and Robert M. Fano as additional senior members. Its goals are to give people personal control over powerful computational resources and to use computation as a catalyst for helping people engage profound ideas from science, mathematics, and the art of intellectual model building. The group's effort is currently focused under DARPA funding on the design of an integrated computational environment which can serve as a programming medium for non-expert users. Other ongoing activities center around the role of computation in educational reform, on the impact of computation in changing the nature of the content of science and mathematics curricula at all levels, and on the use of computation in MIT's undergraduate program.

The fourth new group, entitled Functional Languages and Architectures (FLA), is led by Professor Arvind and includes Research Associate Robert Thomas in its leadership. Group goals entail the use of dataflow principles as a basis for structuring distributed systems and for exploiting parallel architectures that facilitate the efficient execution of functional language programs, including those requiring dynamic resource allocation. Functional languages provide support for advanced programming methods and simplify detection of parallelism in programs. Currently the group is designing, under DARPA funding, a prototype for a one thousand-processor dataflow machine.
Our major Laboratory focus on geographically distributed systems has continued to occupy the attention of more than half of our staff. We have completed our design of a powerful personal computer that can employ different microprocessors as the technology of the latter progresses. This design was successfully transferred to Western Digital Corporation for manufacture. In the coming year, we expect to acquire over 100 such "advanced nodes," which we will use as direct research vehicles in some seven Laboratory research groups, and as general tools for the office automation of LCS.

Our research in distributed computing can be viewed as a search for equilibrium between the opposing forces toward centralization and decentralization—centralization since it maximizes order by vesting authority in one locus, and decentralization because of people's inherent need to control and use their own resources. We believe that increasing decentralization will have a significant effect on the field of computing in that: 1) it will make possible larger numbers of intercommunicating computational resources, and 2) it will permit acceptable operation of the aggregate system in spite of failures of local nodes.

The Laboratory's Distinguished Lecturer Series, initiated in 1976, has proved very successful in attracting members of the MIT community. The 1980-81 lecturers under this series were: Edson D. deCastro (President, Data General Corporation), Richard W. Hamming (Adjunct Professor, Naval Postgraduate School), Grace M. Hopper (Captain, Naval Data Automation Command, US Navy), Richard M. Karp (Professor of Computer Science, University of California at Berkeley), William A. Norris (Chairman and Chief Executive Officer, Control Data Corporation), Louis Pouzin (Director, Pilot Project, Institut National de Recherche d'Informatique et d'Automatique), and William A. Wulf (Professor of Computer Science, Carnegie-Mellon University).

During 1980-81, LCS became the research home of the following faculty members: Professor Charles E. Leiserson of the Department of Electrical Engineering and Computer Science, Professors Ravindran Kannan and Michael Sipser of the Department of Mathematics, and Professor diSessa of the Division for Study and Research in Education. John J. Hynes, former Administrative Officer of the Department of Nuclear Engineering, also joined the Laboratory as Administrative Officer.

New research results developed during 1980-81 were published through the Laboratory's Technical Reports (TR240-TR262) and Technical Memoranda (TM168-TM198), and through several 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 (LIDS) is to carry out basic and applied research in the general area of complex engineering and socio-technical systems. Research areas include theoretical development and selected applications involving the analysis and design of complex dynamic and stochastic systems and networks. 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, applied mathematics, and information systems technology.

The Laboratory was founded in 1939 and played a major role in the development of servomechanisms during World War II and the post-World War II period. Its name was changed from Servomechanisms Laboratory to Electronic Systems Laboratory (ESL) in 1959. Until March 1, 1978, ESL was a departmental laboratory in the Department of Electrical Engineering and Computer Science. On March 1, 1978, ESL was designated as an interdepartmental laboratory and now reports to the Office of the Provost. On September 20, 1978, its name was changed to Laboratory for Information and Decision Systems to reflect more accurately the research interests of its faculty, full-time research staff, and students.
The director of LIDS is Professor Michael Athans, the associate director is Professor Robert G. Gallager, and the assistant director is Professor Alan S. Willsky; all three are members of the Department of Electrical Engineering and Computer Science. In the past year, 19 faculty members, seven visiting faculty, 10 full-time research staff, four visiting scientists, 13 support staff, and approximately 80 graduate and undergraduate students from several MIT departments have been affiliated with LIDS. Research support has been provided by the American Newspapers Publishers Association, the National Aeronautics and Space Administration, the Defense Advanced Research Projects Agency, the Department of Transportation, the Gannett Foundation, the Office of Naval Research, the Army Research Office, the Department of Energy, the National Science Foundation, the Air Force Office of Scientific Research, the Library of Congress, the National Library of Medicine, the General Accounting Office, the General Electric Company, the Dupont Company, and Systems Control, Inc.

In the past year the LIDS research budget exceeded $2 million, and more than 90 new journal and conference articles and research reports were generated. A more detailed description of the research is available from the LIDS publications office (Room 35-311).

RESEARCH

Systems, Estimation, and Control Theory

A major area of research deals with systems and control theory. The objectives of this effort are to provide a fundamental understanding of complex stochastic and dynamic systems, as motivated by several applications, and the development of methodologies, theories, and tools for their analysis and design. Significant advances in the state of the theory and design methodologies were made in the past year in the following research topics: 1) improved understanding of time-domain and frequency-domain approaches to multivariable control system synthesis; 2) novel results in the characterization of robustness of control systems performance to large parameter variations and unmodeled dynamics; 3) theory of stochastic and adaptive control based upon concepts of stability theory and dynamic optimization; 4) nonlinear estimation theory and the analysis of spatially distributed random processes; 5) optimal control theory for distributed parameter systems described by partial differential equations; 6) estimation, control, qualitative analysis, and hierarchical modeling for systems with a hybrid state space that involve the dynamic interaction of continuous and discrete-valued state variables (event-driven systems); 7) fault-tolerant control systems and reliable control system synthesis methods, including analytical redundancy techniques, failure monitoring, detection, and isolation algorithms; 8) microprocessor-based sampled-data control system issues, including the issues of finite word-length and computer architectures; 9) the theory of large-scale stochastic dynamic control systems under distributed control, including theoretical results on organizational, communications, and computational issues; 10) optimization algorithms for both static and dynamic optimization problems; and 11) dynamic game theory.

Communications Networks and Systems

A second major research area at LIDS deals with issues that arise in complex communications networks. This research is motivated by the increasing use of both civilian and military data communication networks (utilizing wire, fiber optics, and radio links) to transmit data or digitized voice messages. The objective of the research effort is to develop the necessary theory and distributed algorithms for the analysis and design methods for such networks. In the past year significant advances were made in the following research areas: 1) development of novel distributed quasistatic algorithms, involving only local computation at each node and nearest neighbor communications, for message routing; 2) combined routing and congestion control strategies; 3) multiaccess channel studies; 4) distributed routing algorithms for radio-packet networks with rapidly changing topology; 5) issues of queuing and flow control that arise in the transmission of digitized speech; and 6) special communication network issues that arise in distributed data based systems.
Command, Control, and Communications (C^3) Systems

A third major research area deals with fundamental understanding of the complex issues that arise in military C^3 systems. This represents a new area of research for LIDS, and was initiated to focus the research in systems and communications in the hope that a theory for C^3 systems can be developed. Progress was made in the following areas: 1) the development of novel distributed detection and tracking algorithms of several objects by diverse sensors in the surveillance C^3 subsystem; 2) development of new time-delay performance models and analysis of query algorithms for distributed data base systems; 3) routing and flow control algorithms that guarantee receipt of broadcast messages in a failing communications network; and 4) distributed decision theory, including organizational theory, to model the interactions of several commanders in an information-theoretic and control-theoretic context.

As an outgrowth of this research LIDS is sponsoring and organizing an annual two-week workshop on C^3 systems. The fourth workshop was held in San Diego, CA, in June 1981.

Transportation Systems

A variety of projects dealing with transportation-related problems are currently under investigation. These include: 1) studies of integrated radio communication and position location systems for urban vehicles; 2) airtraffic control studies, with special emphasis on 4DRNAV; and 3) transportation network optimization studies.

Energy Systems

A diverse variety of research investigations have been carried out in the general area of energy systems. Progress has been made in the following areas: 1) multivariable control strategies for AC power networks using multiterminal DC links for power flow dynamic modulation; 2) fundamental understanding of stability issues in power networks so as to develop mathematical models and techniques to abstract severe phenomena such as blackouts and islanding; and 3) power system effectiveness studies that include deterministic and stochastic representations of feasible loads, and the development of measures of effectiveness for the capability of a power system to supply service, taking into account reliability and costs.

Manufacturing Systems

The goal of this research effort is to develop relevant analysis and design tools for complex manufacturing systems, with special emphasis upon flexible manufacturing systems (FMS). Progress has been made in the following directions: 1) evaluation of production rates for transfer lines as a function of buffer capacities, and machine failure and repair rates; and 2) routing and scheduling strategies in FMS machine networks, with emphasis upon the development of optimal and suboptimal real-time control strategies. Many of the previously developed analysis and design algorithms have been implemented in an interactive industry-user-oriented software package (FLEXMAN) so as to facilitate technology transfer. Several industrial engineers have used FLEXMAN in the past few months.

Information Systems

Research has continued in the area of computer intermediary systems for networking interactive retrieval systems. Progress has been made in investigations of computer aids that automatically or interactively assist users in: 1) formulation of search strategies; 2) selection of databases; and 3) translation of strategy to host-system commands. Initial evaluation of experiments with computer-inexperienced end users shows prospects for designing computer intermediaries that are as effective in the retrieval process as human-expert intermediaries.

The electronic interlibrary-resource sharing project has shown substantial progress. A system configuration has been conceptualized for ordering, electronically transmitting, and reproducing documents within a regional network of libraries. A key element of the network is a bound-volume
document scanner, a working model of which has been developed for experimental purposes; also we are investigating data-compression schemes as a preliminary to the selection of an optimum approach for this application.

Aerospace Systems

Several projects that deal with different aircraft-related problems are under investigation:
1) methods to compensate for vertical and horizontal wind sheer effects in transport landings;
2) simulation of a control-configured F-16 aircraft to evaluate various display formats for better utilization of the aircraft's direct force control capabilities; 3) reliable control strategies for landing a Vertical Short Takeoff and Landing (VSTOL) aircraft on the deck of a D963 destroyer under high sea-state conditions; and 4) adaptive control system designs for high-bypass jet engines.

Numerical Methods and Software

Basic research is continuing on the development of numerical methods and algorithms for solving generic problems in linear algebra, statistics, and control. These algorithms are implemented as robust mathematical software that is operational without modification on many different computing machines. Progress has been made in the area of robust statistical computing (dynamic determination of numerical rank, and iteratively reweighted least squares problems) and in robust computing for the solution of control problems. As an outgrowth of this research LIDS is sponsoring and organizing an annual two-week summer research conference on numerical and statistical computing; the second one was held in June 1981 at the University of Delaware Conference Center, Newark, Delaware.

Personnel and Honors

Professor Sanjoy K. Mitter has been appointed director of LIDS, effective September 1, 1981, to replace Professor Michael Athans, who will return to full-time teaching and research.

Professor Wilbur B. Davenport, Jr., was the co-recipient of the 1981 Pioneer Award of the Institute of Electrical and Electronics Engineers (IEEE) Aerospace and Electronics Systems Society. The citation was "For pioneering contributions and leadership in the development of spread-spectrum communications technology."

Professor Athans was the recipient of the Second Education Award of the American Automatic Control Council. The citation was "In recognition of outstanding contributions and distinguished leadership in automatic control education."

Professor Willsky received the 1980 IEEE Browder Thompson Award for his paper "Relationship Between Digital Signal Processing and Estimation and Control Theory" published in the IEEE Proceedings.

Graduate student Mostafa Ammar won the second prize of the Operations Research Society of America (ORSA) Nicholson student paper competition for his paper "Equivalence Relations in Queueing Models of Manufacturing Networks."

MICHAEL ATHANS

Libraries

In order to flourish and not merely to survive, a large and complex organization such as the MIT Libraries must engage in a variety of activities, both intellectual and operational, in a coordinated and synergistic manner. The process of integrating the functions of collection development, provision of reference and bibliographic services, analysis, evaluation, and
planning is what makes life in an academic research library usually exciting and stimulating but sometimes quite frustrating. This report highlights some of the major activities of the Libraries in each of the areas described above during the past twelve months.

The larger context in which the MIT Libraries operate consists of, in the first instance, the community of academic libraries in the United States and Canada that have as their mission the support of teaching and research in what has generally been accepted as "research universities." The Libraries also interact closely with the set of academic, public, and special libraries in the six New England states, with the group of libraries in the Boston Library Consortium, with publishers, with learned societies, and with industry. The complex set of issues, both immediate and future, that are the common interest of these groups in the fields of library and information science forms the intellectual and technical framework in which the MIT Libraries function. The future of automation as applied to library activities, for example, is inextricably tied to programs and plans of the New England Library Information Network (NELINET), and of its parent organization, the Online Computer Library Center, Inc. (OCLC). Likewise, future developments in cooperative collection development will probably emanate from organizations like the Association of Research Libraries and the Boston Library Consortium. Improvement of the economic situation in research libraries is dependent in large measure upon the successful interchange of ideas between librarians, publishers, learned societies, and the government. Finally, changes in the ways that research libraries collect, process, store, and disseminate information are a product of the collective and individual imagination and intelligence of the library profession. That the MIT Libraries are very much a part of all these interconnections and efforts is evident from the activities listed in this report.

Two major library projects, long in the planning and feasibility study phase, emerged during the past year as full-fledged programs. The first, an electronic security system for the four major library buildings (Hayden, Barker, Dewey, and Rotch) will be installed in the fall of 1981. The aim of this system is to increase the availability of library materials by reducing the unauthorized removal of books, journals, and other materials from the Libraries. The second was the development of a proposal for an automated circulation system for the MIT Libraries. Subject to funding by the Institute, this system will initially provide for a computer-based circulation system in all public service units with future capacity as an online catalogue, acquisitions system, and intra-library communication network.

Another major effort during the year was the completion of the microfilming of the Dewey Decimal Catalogue covering the Libraries' acquisitions from 1860 through 1964 and the placement of a complete set of microfiche representing this file in each public service department. A staff study was undertaken on the use of word processing equipment in the Libraries and recommendations are expected to be implemented during the coming academic year. The director and assistant director for Public Services worked closely with a group of faculty and administrators in planning library facilities and services in Whitaker College.

The Libraries have been spending a considerable amount of time during the past year addressing the interconnected questions of internal communication, organizational structure, and long-range planning. During the summer of 1980 and in June of 1981, members of the Library administration met with groups of staff to identify areas of concern; the matters of planning and organizational structure were high on the list. The Library Council devoted a number of its biweekly meetings to an analysis of its own organization and function. Among the first results of these activities were 1) the appointment of five subgroups of Library Council to identify long- and short-range issues in the areas of technology, long-range planning, evaluation of library services, space and physical facilities, and committee structure and staff participation; 2) clarification of the roles of the Library Council, Steering Committee, and various committees and task forces in the decision-making process; and 3) initiation of plans for a Library Council "retreat" in early fall of 1981.

A major portion of staff time and energy over the past year has been devoted to planning for implementation of the second edition of the Anglo-American Cataloguing Rules (AACR2). Workshops for public service and other non-cataloguing personnel were held during the summer to present the major rule changes and to explore their impact on access to and arrangement of the collection. During the fall, the Catalogue Department conducted training sessions where individual rules were analyzed and implications explored. In December, the AACR2 Implementation Task Force, composed of both public and technical services staff, was formed to make policy recommendations for implementation of the new cataloguing rules. The Task Force has made
recommendations concerning the integration of AACR2 catalogue records into the existing card catalogue through a variety of techniques including interfiling, record changes, and maintenance of split files. Subgroups of the Task Force have been dealing with the complex issues of serials, monographic series, and music. The development of the policy statements is the first phase of the implementation process. Individual procedures are being developed by the Acquisitions and Catalogue Departments and the Divisional Libraries to carry out the recommendations of the Task Force. The year ahead will see continuation of the procedure-writing, review, and testing process.

While considerable progress was made in connection with one of the Libraries' major space problems -- the Resource Sharing Center -- two other critical areas remained major concerns with the possibility of solution still somewhat distant. The acquisition of a building on State Street and Massachusetts Avenue, formerly owned by Nabisco, will provide the Libraries with a permanent home for its Resource Sharing Center. Following renovations and the installation of stacks and other equipment, collections now housed in Buildings N51 and N52 will be transferred, and additional materials from other library units will be moved to that facility. The Rotch Library space situation has continued to worsen, and users of that library suffered through the first full year of having a significant percentage of relatively current material stored at the Resource Sharing Center. The director of Libraries met with the Committee for Review of Space Planning during the year to discuss the existing situation and review possible solutions. The Music Library continues to be extremely pressed for space, but it seems likely that within the next year the Libraries will be able to recover the Music Seminar Room and use that space for additional materials storage. A new set of offices was created on the third floor of Building 10 as the permanent home of the staff of the Aga Khan Documentation Center and Documentation projects. Two pressing space-related problems that will be addressed during 1981-82 are improvement of the Libraries' internal delivery system, and contingency planning for the move of the rare book collections now stored in the McKim Building of the Boston Public Library.

Among the other major organizational and operational developments during the past year were the following:

- The position of assistant director for Collection Management was created with responsibility for oversight of the technical services operations of the Libraries and coordination of collection development. The acquisitions functions of the former Collections Development Department were centered in a new Acquisitions Department.

- The second review of the Collection Analysis Project was undertaken with the goal of identifying areas where additional effort is needed to strengthen the concept of coordinated collection development.

- Design and implementation of an orientation program for library staff.

- Completion of the Librarian Staff Handbook. Several sections of this document will be issued separately as part of the orientation packet for all new staff.

- The name of the Historical Collections unit was changed to MIT Museum and Historical Collections, to reflect more accurately the mission and programs of this department.

- Access to computerized bibliographic information was extended by the installation of an OCLC terminal in the Humanities Library and a CRT terminal and printer in the Science Library.

- Four additional coin-operated copy machines were installed; one each in the Hayden, Barker, and Dewey Libraries, and one in the Chemistry Reading Room.

- The Rotch Library staff developed and delivered a teaching module in library methods for the Department of Urban Studies and Planning.

- Plans were completed under the aegis of the Reference and Information Services Committee for an undergraduate seminar in library methods to be given during the 1981 fall semester. The seminar is entitled "Research Methods: Attaining Bibliographic Literacy."
Among the library contributions to the 1981 Independent Activities Period were the Fifth Annual MIT College Bowl; a series of four lectures on desegregation of public schools in Boston; three sessions on architectural drawings as historical documentation; and seminars on finding a job, on micrographics, on census data, on the care of rare materials, and on thesis preparation. Other offerings were devoted to music, flower arranging, Oriental carpets, and needle crafts.

The Libraries sponsored a symposium on recent developments in library and information science for representatives of organizations belonging to the Institute's Industrial Liaison Program. Speakers covered such areas as on-line data bases, copyright, networking, archives, micrographics, and current research at MIT in electronic document delivery.

Efforts continued toward the implementation of staff recommendations regarding a coordinated sign system in the area of government documents.

Several major personnel changes were made during the past year, including three among the senior library administration. Thomas L. Wilding, formerly on the staff of the Smithsonian Institution Libraries, was appointed assistant director for Administrative and Personnel Services. Susan K. Nutter was appointed assistant director for Collection Management, having been promoted from the position of associate engineering librarian. Suanne W. Muehlner, assistant director for Public Services and a member of the MIT Library staff for more than 15 years, was appointed director of the Colby College Library in Waterville, Maine, effective September 1, 1981. Other personnel actions included the promotion of Clara-Mae Chittum to the position of head of the Acquisitions Department, and the appointments of Lisa M. Kamisher as documentation specialist in the Aga Khan Program for Islamic Architecture, Elizabeth A. Margutti as Department of Transportation librarian in the Science Library, and Theresa A. Tobin as assistant humanities librarian. Promoted to staff positions were Marcia E. Conroy, curator of education in the MIT Museum, and Susan L. Durante, business manager for the Microreproduction Laboratory.

During the 1981-82 academic year, the Libraries will host a Council on Library Resources Academic Library Management Intern. This is the second time that the MIT Libraries have been selected for this program. Working with the director and senior administrative staff will be Karen Wittenborg, Social Sciences Bibliographer at Stanford University.

The Libraries continued to participate in a number of research activities, the most significant of which were the continuation of the National Endowment for the Humanities (NEH) grant to the Institute Archives; the Boston Area Music Librarians project on Boston composers, also supported by NEH; and a variety of projects in the area of Islamic architecture centered in the Aga Khan Documentation Center. Several members of the staff continued to work closely with Professor J. Francis Reintjes in the development of a proposal in the area of electronic document delivery. Late in the academic year, the MIT Libraries were notified by the National Science Foundation (NSF) that funding was likely for a project that would establish appraisal guidelines for scientific and technical records.

The major administrative changes that took place at MIT during the past year resulted in the acquisition of several important collections by the Institute Archives. The retiring President, Jerome B. Wiesner, and the outgoing Provost, Walter A. Rosenblith, transferred their official files soon after the beginning of the academic year. The records of the Office of the Chancellor were also deposited by President Paul E. Gray. Other important collections of personal papers were acquired from Professor Frank Press and Professors Emeriti Roman Jakobson, William Ted Martin, Harold E. Edgerton, and Manson Benedict. Professor Carroll L. Wilson transferred additional personal papers, and records of the Workshop on Alternative Energy Strategies, and the World Coal Study. The law firm of Kenway and Jenney transferred to MIT the records of the core memory patent litigation.

Additions to the Libraries' printed collections included a collection on folklore and folk music belonging to the late Charles R. Keppel, Class of 1959, and former professor of chemistry at the University of Nebraska, donated by his wife; books in the field of transportation economics from the estate of James R. Nelson, professor of economics at Amherst College; and a large number of books, journals, reports, and maps from Professor Press. The Rotch Library received a large collection of books, slides, and art objects from the estate of Kenneth Kaiser, Class of 1964.
Two noteworthy gifts to the MIT Museum came from Mr. and Mrs. Archie Riskin, who donated a 35-foot long artistic rendering of the Boston skyline by Lawrence Sisson; and Texas Instruments, who gave 13 calculator models of historical interest to add to the Museum's growing collection.

The Libraries still face a considerable number of critical issues, not the least of which is the continued pressure of the combined forces of inflation and expanding levels of publication, but the prognosis for progress is extremely positive. This expectation is due in large measure to the availability of a dedicated and conscientious staff, a most supportive Institute administration, and the ongoing interest of faculty, administration, students, and friends, to all of whom the Libraries express appreciation.

JAY K. LUCKER

Lowell Institute School

The Lowell Institute School (LIS) was established at MIT in 1903 to provide evening instruction in technical subjects for residents of the Boston area. Today the School continues this tradition by offering subjects in the areas of modern technology which are not readily available at other evening institutions. The general level of instruction is geared to the practicing technician who has an Associate degree or equivalent experience.

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

During 1980-81, LIS offered 29 evening courses in both the fall and spring terms. The fields of instruction included Analog and Digital Electronics; Microprocessors; Applied Mathematics; Math for Drafting and Machine Shop; Mechanical, Electrical, and Architectural Drafting; Fundamentals of Quality Assurance; Creative Photography; Machine Tool Fundamentals; Numerical Control; Principles of Metal Joining; Printed Circuit Board Design; Scientific Glassblowing; and Energy Alternatives. In addition, new courses were introduced in Blueprint Reading, Advanced Microcomputer Applications, Welding/Fabricating Technology, Creative Photography II, and Effective Speaking.

LIS continued to offer intensive one-week daytime courses for individuals working in industry. Two courses in Advanced Microcomputer Applications were conducted during January and June. One introductory microprocessor course was offered in cooperation with the Boston Section of the Institute of Electrical and Electronics Engineers. Another unusual activity this year was the photographic exhibition by the Creative Photography students held in the gallery at the Piano Factory in Boston.

LIS admitted a total of 1,299 students to its courses in 1980-81, 1,227 to the evening classes and 72 to the intensive daytime courses. Of those who enrolled, 75 percent successfully completed the certificate requirements. Among those who completed courses were 40 MIT employees and four regular MIT students. Five students earned the Special Certificate in Electronics Technology, and seven students the Special Certificate in Drafting Technology. In order to qualify for these special certificates, students must complete a specified program of study.

The past academic year has seen LIS expand its program of unique evening courses which no other Boston-area school can match. Enrollment has increased for the eighth 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
Mining and Minerals Resources Research Institute

The 1980-81 academic year is the third year of existence of the Mining and Mineral Resources Research Institute (MMRRI). Support for the program comes from the Office of Surface Mining, US Department of the Interior, in three parts: an institutional grant, a grant for fellowships, and for research contracts. In addition, as a result of seed money supplied from the institutional grant, support by industry of two research programs related to mining has been obtained this year. Comments on these latter programs will be included later in this report.

The activities of the MMRRI for the past year continued to reflect the interdisciplinary nature of the program, and the desire to use our resources to initiate new programs and educational activities at MIT that are related to mineral resources.

This year eight graduate students have received financial support from the fellowship grant. Their affiliations include the Departments of Civil Engineering, Earth and Planetary Sciences, Economics, Materials Science and Engineering, and Mechanical Engineering. Fellowships are awarded to students who are pursuing studies that relate to mineral resources with preference accorded to graduate students working with newly appointed faculty members who have as yet little support for their own research; and to entering graduate students with a strong interest in mineral resources, but who are not sure of the kind of research that he or she eventually wishes to undertake as a research topic.

An important commitment of funds from our institutional grant has been made to initiate a program on mineral engineering in the Department of Materials Science and Engineering. These funds provide a major portion of the support of Professor Terry A. Ring, a newly appointed faculty member in the department. The support allows him to direct the major part of his efforts to develop classes in mineral engineering and to begin a research program in that field. With joint support from the Sloan Fund, we have also purchased some capital equipment for his work; the most important item being a photon correlator for studying the behavior of aqueous slurries containing submicron-sized particles.

Seed money from the MMRRI also has been of help in the establishment of two new laboratories at MIT for work on mining and mineral resource development. The first is the Laboratory for Mining Systems Development in the Department of Mechanical Engineering, which is headed by Professor Carl R. Peterson. This Laboratory is wholly funded by private industry, and its purpose is to develop innovative mine and mine-machinery systems. The second is the "REMERGENCE" Laboratory (a Laboratory for experimentation in Resource Extraction, Materials and Energy, Reservoir, Geotechnical, and Environmental and Construction Engineering). This is a joint activity by faculty and graduate students in the Departments of Mechanical and Civil Engineering, and is led jointly by Professors Michael P. Cleary and Herbert H. Einstein.

There are many research activities at MIT that are related to mineral resources. We are fortunate also to have obtained support from the Office of Surface Mining for four research projects this year. Support was awarded on a competitive basis by the office for the following four programs: "Probabilistic Methods of Mineral Exploration," Professors Rafael Bras and Daniele Veneziano, and "Combined Stability -- Deformation Analysis for Rock Slopes in Open Pit and Strip Mines," Professors Einstein and Gregory B. Baecher. Both projects are in the Department of Civil Engineering. The other two programs are "Fast Fluidized Beds in Minerals Processing," Professor John F. Elliott, and "The Competitive Position of the United States Copper Industry: 1980 - 2000," Professor Joel P. Clark. Both projects are in the Department of Materials Science and Engineering.

To encourage greater participation of members of the faculty in professional societies related to mineral resources, funds for travel to professional meetings were provided in a number of cases. The MMRRI was also one of the sponsors of the 22nd US Symposium on Rock Mechanics that was held at MIT from June 29 to July 2, 1981.
The Neurosciences Research Program (NRP) is an international, interuniversity, and multidisciplinary organization operating as a research center of MIT. 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.

To carry out NRP's activities, 36 scientists, leaders in major neuroscientific disciplines, are elected to serve as NRP Associates to provide advice and guidance to a small professional staff at the NRP Center in Boston, Massachusetts. NRP also enlists participation in its activities by scientists from the neuroscientific community at large.

During the 1980-81 academic year, progress was made in the reorganization of NRP and planning for its move to Rockefeller University. During the forthcoming academic year 1981-82, there will be two centers of NRP operations, the final year of the MIT Center in Brandegee House, and the start-up year for the on-campus NRP Center at Rockefeller University. Effective July 1, 1981, Dr. Vernon B. Mountcastle replaces Dr. Frederic G. Worden as director of NRP. Dr. Worden will continue as deputy director and principal investigator on the Federal research grants in support of the MIT operations of NRP, which will be terminated effective August 1, 1982.

The biannual stated meetings of NRP Associates are a major component of the scientific program. For the October 1980 stated meeting, a multidisciplinary and multilevel attack on the question of neural mapping was organized by A.M. Graybiel and M. Konishi. Discussion concerned the nature of brain maps (led by D.H. Hubel, M.M. Merzenich, and M. Konishi), the origins of maps (led by H.J. Karten, J.M. Allman, H. Van der Loos, and P. Rakic), and constraints and requirements of mapping (led by J.J. Hopfield, G.M. Edelman, and F.H.C. Crick).

An additional feature of the program was an inaugural address by J.B. Martin, "Neuroendocrine Regulation of Episodic Growth Hormone Secretion."

For the March 1981 stated meeting, D.E. Koshland organized a diverse program of discussions seeking to integrate molecular-chemical ("wet") and structural-physiological ("dry") approaches to problem areas. In response to a series of short presentations, there was vigorous and multidisciplinary discussion in the informal and collegial style that epitomizes NRP at its best.

Additionally, R.H. Held gave an inaugural address, "Development and Plasticity in the Visual System of Human Infants."

The following conferences, work sessions, and special projects (chairpersons in parentheses) were held during academic year 1980-81: "Development and Modifiability of the Cerebral Cortex," (Pasko Rakic and Patricia Goldman-Rakic); "Mechanisms and Functional Implications of Hippocampal LTP," (L.W. Swanson, T.J. Teyler, and R.F. Thompson); F.O. Schmitt Lecture in Neuroscience, given by Rita Levi-Montalcini, "The Nerve Growth Factor: Retrospective and Perspective Views"; "Neurobiology of Language Processes," (H. Goodglass and M.G. Studdert-Kennedy); and a special five-day meeting, "Molecular Genetics and Neuroscience: A New Hybrid," (F.O. Schmitt, F.E. Bloom, and S.J. Bird).

Dr. Gerald D. Fischbach was elected an NRP Associate at the March 1981 stated meeting.

FREDERIC G. WORDEN
Northeast Radio Observatory Corporation
Haystack Observatory

The Northeast Radio Observatory Corporation (NEROC), is 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, MIT's Haystack Observatory, from the National Science Foundation (NSF), and project support from NSF, the National Aeronautics and Space Administration (NASA), and the other Federal agencies, and it uses the administrative services of MIT in the conduct of its business. Observing proposals submitted by prospective users are considered by a review committee, on the basis of scientific merit and suitability 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-, 13-, 6-, 3.8-, 3-, 2-, 1.35-, 1.07-, 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.

In the past year, the telescope was used by approximately 80 investigators from over 20 different institutions, and 50 articles were published in scientific journals based upon this work. Approximately 20 percent of the telescope usage was by MIT faculty and their students. The low-noise, high frequency receivers and the wideband, high resolution digital correlation spectrometer are crucial to these observations. One of the interesting results has been the initial detection of the heavy cyanopolyene HC$_{11}$N in the circumstellar envelope of the star IRC 10216. Three separate rotational transitions of the molecule were observed in the frequency range from 23-25 GHz. The dense cores of dark clouds, possibly the sites of future star formation, have been studied using the inversion transitions of NH$_3$. These transitions of NH$_3$ are closely spaced in frequency yet require widely differing conditions for excitation. Molecular cloud parameters such as temperature and density, as well as dynamical information, are easily obtained from observations of the NH$_3$ molecule. A possible example of a cloud-cloud collision-inducing star formation has been observed using NH$_3$ measurements in the ionized gas complex W33. Other programs have included studies of the properties of interstellar masers at 43 GHz (SiO) and 22 GHz (H$_2$O).

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 interferometer fringes. For astrometry and studies of complex source structure, VLBI provides resolution not attainable by any other means. "Superluminal" expansion in quasars, which was first discovered in VLBI observations between Haystack and the 64-meter telescope at Goldstone, California, in 1971, has been even more clearly illustrated in maps of the quasar 3C273 made from VLBI network observations (see the cover of the 2 April 1981 issue of Nature). Haystack is a member of the VLBI network of seven observatories which make astronomical VLBI observations every two months. The network

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*Boston University, Brandeis University, Brown University, Dartmouth College, Harvard University, MIT, 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.
Office of Minority Education

uses the Mark III VLBI system and the Mark III processor at Haystack for high sensitivity measurements. VLBI studies carried out using the Mark III have included mapping the compact radio source in the center of our galaxy and in the nearby galaxy M81. Other objects studied include the strange galactic object SS433 which shows rapid time variations in its structure, the gravitational images of the "twin quasar" 0957+56, and several "flare" stars.

With support from NASA, VLBI is being used to make precise geodetic measurements between Haystack, the 40-meter telescope at Owens Valley Radio Observatory, California, the 26-meter telescope of the Harvard College Radio Observatory in Fort Davis, Texas, the 100-meter telescope of the Max Planck Institute in Bonn, Germany, and both the 26- and 25-meter telescopes of the Chalmers Institute of Technology in Onsala, Sweden. The measurements, which are part of the NASA Crustal Dynamics Project, have established that the drift rate across the North American tectonic plate (Haystack-Owens Valley) is less than 1cm/year. In a few years it is expected that the baseline measurements will establish an intercontinental drift rate between the North American and European plates. The experiments, which have centimeter-level accuracy, use the new Mark III VLBI system, and observations are made simultaneously at two frequencies (2.2-2.3 GHz and 8.1-8.6 GHz) to eliminate the propagation effects in the ionosphere.

During 1980-81, Haystack Observatory assumed responsibility for the 60-foot diameter Westford antenna located one mile south of the 120-foot telescope. This smaller instrument was previously operated by Lincoln Laboratory as a radar and experimental antenna, and was used by Haystack investigators to prove the accuracy of geodetic VLBI measurements by direct comparison with conventional surveying techniques. With funding from the National Geodetic Survey (NGS) and NASA, this telescope has been extensively refurbished and modernized. Now fully equipped with a computer-controlled pointing system, receivers for the two and eight GHz bands, and a Mark III VLBI terminal, the Westford telescope is operational as a dedicated station for the NGS project Polar Analysis by Radio Interferometric Surveying (POLARIS). The object of POLARIS is to measure changes in the absolute rotation rate of the Earth by measuring UT1, and to measure the changing point of intersection of the Earth's axis and the crust, or polar motion. Along with an existing station at Ft. Davis, Texas, the Westford antenna is monitoring these parameters on a weekly basis. A third site at Richmond, Florida, is now under development by NGS, and will increase the accuracy of the results. It has been shown that VLBI measurements of UT1 and polar motion are an order of magnitude more accurate than other techniques, and are not subject to the vagaries of weather as are satellite-laser and classical optical methods. These quantities are of practical importance in timekeeping, surveying, and navigation, as well as being of fundamental interest to Earth science.

JOHN V. EVANS

Office of Minority Education

The Office of Minority Education (OME) has carried out a number of programs and activities in order to expand the educational resources available to minority students, and to increase the number of minority students who graduate successfully. During the 1980-81 academic year, Clarence G. Williams served as acting director of OME. He also retained his position as Special Assistant to the President. Pearlne D. Miller served as assistant director.

The Office also provides a center for student activity and informed student support. It has been very capably staffed by Gloria Payne, administrative assistant, and Mireille Desrosiers, secretary, and has profited from the services of several student staff members.

OME received the counsel of students, faculty, and staff throughout the Institute. The Student Advisory Group provided input to the Office regarding student concerns. They advised the Office on existing programs and suggested activities such as our "Open House" which was implemented in the spring term.

The search for a director of OME continued. Meetings were held at various times during the year, and several candidates were interviewed.
Project Interphase

Structurally, this program remained unchanged from last year. There were 48 participants during the 1980-81 academic year. Professor Alan Davison continued to supervise the academic content of the program, and Mrs. Miller had responsibility for overall direction of the program.

Students received intense academic preparation in chemistry, humanities, mathematics, and physics. A formal introduction to the resources of the Institute, and to general academic skills, was also provided. Group athletic and social activities were planned for students and staff. Tutors for the program lived in the dormitory with the students and were thus able to provide effective assistance and support. Student evaluations were given to the students during the last week of the program to get feedback on the effectiveness of all aspects of the program.

A 15-page survey-questionnaire, usually distributed by OME in the fall term, was distributed in early spring to seek students' impressions of the impact of Project Interphase 1980-81 on their MIT experiences to that point, to help the Office plan for Project Interphase 1981-82, and to help build more effective academic support services for minority undergraduate students.

Black Student Union Tutorial Program

The Black Student Union (BSU) Tutorial Program continued to provide tutorial assistance to undergraduate students. The student coordinators were Laura-Lee Davidson and Rosemarie Wesson. The tutors are graduate students and upperclass undergraduates; their services are coordinated by the student coordinators and program secretaries under the general supervision of Mrs. Miller. In 1980-81, the program provided over 4,900 hours of tutoring in more than 60 subjects.

The tutorial program celebrated its 10th anniversary with the performance of a skit which tracked its beginnings, growth, continued use and importance to students, and the increase in the number of subjects tutored.

The Freshman Buddy System continued this year as part of the BSU Tutorial Program, and was coordinated by Iranc6 Reddix. Upperclass students serve as "buddies" to several assigned first-year students and are expected to contact them weekly to offer friendly support and to encourage the use of Institute services.

Freshman Watch

With the cooperation of the faculty and staff teaching science requirement subjects, freshmen have been asked, as needed, to come into OME for academic counseling and tutorial service. This program supplements the activities of the freshman advisors, and communication with each freshman advisor is maintained.

Second Summer Program

This program is offered to selected freshmen on completion of their first year at MIT. It provides industrial exposure combined with on-campus academic experience. Nine students worked for 10 weeks at E.I. duPont de Nemours & Co., Goodyear Tire & Rubber Co., and Monsanto Co. On completion of their industrial experience the students returned to MIT for the academic component. The primary focus of the academics was on problem-solving techniques, differential equations, and academic planning. The Second Summer Program has been very well received by the students. The number of participants for 1981 has increased to 17 students and four companies.
Activities

During the past year, OME sponsored a number of seminars and assisted students in planning various activities. These included: R/O Week activities in cooperation with the BSU and the Mexican American Students Association, with the objective of making the transition into MIT as smooth as possible; seminars on time management and academic planning, interview techniques, resume writing and employer expectations; an IAP seminar to teach students how to prepare for the Medical College Admission Test; sponsoring student representatives to attend national conventions of professional societies; and continuing to sponsor a student-produced videotape about minority student life at MIT.

Awards and Gifts

OME selected Nathan Graham 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 prize given by the Monsanto Company "to promote academic excellence among minority engineering students at MIT."

OME received gifts from the following companies to further activities aimed at increasing the number of graduating minority engineering students: American Can Co., Bethlehem Steel Company, E.I. duPont de Nemours & Co., Goodyear Tire & Rubber Co., Hewlett Packard, and Monsanto Industrial Chemical Co.

CLARENCE G. WILLIAMS

Operations Research Center

The Operations Research Center (ORC) conducts interdepartmental academic and research programs in the field of operations research. The academic staff of the Center is drawn from many departments, including the Sloan School of Management and the Departments of Electrical Engineering and Computer Science, Urban Studies and Planning, Aeronautics and Astronautics, Civil Engineering, Mechanical Engineering, Ocean Engineering, Mathematics, and Physics. At present, approximately 20 students are in the operations research doctoral program and a comparable number are in the master's programs. Most of them come to MIT 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 a range of basic and applied research sponsored directly by the Center and, in part, by other laboratories at MIT. Basic research was carried out in the areas of mathematical programming, optimization, network or graph theory, and statistics. Applied research projects included those in operations management, marketing, energy systems, transportation systems, urban systems, public program evaluation, and criminal justice systems.

Research was expanded in the application of operations research to industrial problems. New results were obtained for several types of facilities location problems, including new methods for their parametric analysis. A project was completed on optimization models and other approaches for the diagnostic analysis of inventory systems. In order to reduce the data collection and analysis requirements of the diagnostics, a methodology for aggregating models was developed and empirically tested to identify the characteristics that items should share to be aggregated into a single family.

Several classes of scheduling problems were studied by members of the ORC staff. New algorithms were developed for periodic models that arise in vehicle and personnel scheduling. Research was completed on a dynamic programming approach for sequencing a given set of
jobs on a single machine, so that the processing cost is minimized. The resulting algorithm was
applied to the optimal sequencing of aircraft loadings at an airport. Research was also completed
on a real-time, interactive computer system for scheduling a paper mill. The system uses
mixed-integer programming and heuristic methods to develop near optimal schedules in which
mill production is balanced among the pulp mill, paper machine, and finishing operations. A
new model was constructed and analyzed for production scheduling over an infinite horizon
when the demands and costs are cyclic.

Operations research models and methodologies were proposed and extended in several areas
of marketing research. One topic was concerned with the problem of how firms can best
defend their position after a competitive new product has entered the market. A quantitative
approach to this problem was developed for estimating consumer response, and evaluating
the new product's position. In another area, continuous-time Markov processes were used to
construct dynamic models of consumer behavior. Practical statistical procedures for implementing
these models were also developed.

Research was completed in a number of topics in the related areas of combinatorics, graph
theory, and complexity theory. New results were obtained relating the complexity of dynamic
languages to dynamic optimization problems. Similarly, the computational complexity of the
capacitated lot-size problem was analyzed to identify those problems which are solvable by
polynomial time algorithms.

Work continued on the merging of location theory with probabilistic processes. The definition
of optimal locations (medians) of a transportation network has been successfully extended to
the case in which travel times on network links are random variables with known discrete
probability distributions. Under reasonable assumptions, it was shown that well known
"facilities at nodes" theories can be extended to such stochastic networks.

Research into the construction and analysis of energy planning models combining mathematical
programming and econometric methodologies was continued. Mathematical programming decomposition
theory was used to integrate an energy sector model with a model of endogenous end-use
demands for energy. The same approach was taken to evaluate the economic impact of new
energy technologies, and to study the macroeconomic linkages between the energy sector and
the economy as a whole.

The ORC staff produced new findings in statistical research, particularly in the areas of
regression diagnostics, nonlinear regression models, and clustering techniques. Single-row
diagnostics for instrumental variables models have been further developed, as well as
diagnostic subset deletion methods. Work continued on programs for generalized nonlinear
regression models based on the binomial, multinomial, and Poisson distributions. A new approach
to clustering was developed using graph decomposition techniques to define natural partitions
of high density clustering models.

Applied statistical research was performed in the areas of health and criminal justice. A
statistical model was developed to estimate the time from induction to diagnosis of radiation-induced
cancer. A Bayesian model for predicting stages in Hodgkin's disease was constructed, and
its validity was evaluated on empirical data. Further research was performed on the deterrent
effects of capital punishment, and the consistency of age-dependent sentencing.

Work continued on a portable, on-line computer program for setting arterial traffic signals.
The program produces cycle time, offsets, speeds, and order of left turn phases to maximize
the weighted combination of band widths. Mixed-integer programming techniques are used in
the optimization.

The ORC staff performed research in several areas of network optimization. An algorithm was
constructed for determining the minimum delay routes in a communication network. The algorithm
is capable of employing second derivatives of link delay functions, thereby providing automatic
scaling with respect to traffic input level. Research was continued into equilibrium problems
which are used to predict traffic flow on a congested transportation network. An extensive
survey was completed of the applications of combinatorial optimization models and techniques
to problems of vehicle routing and fleet planning.
Basic research was completed in a number of areas of mathematical programming. New nonlinear programming algorithms were devised which use projected Newtonian and variable metric methods. These algorithms were applied and empirically tested on network flow and optimal control problems. A new duality theory for nonlinear multiple-criteria optimization problems was developed. This theory associates matrices rather than vectors with efficient points. Multiple-criteria methods were also applied to facility location problems. The final selection of efficient points for these problems is made by integrating the decision maker's utility function.

Basic research continued into the structure of integer programming problems. The goal was to derive results explaining, at least in part, why some integer programming problems of a given size and structure are much more difficult to solve than others. A related question being studied is why a particular integer programming problem formulation is easier to solve than another equivalent formulation. Other integer programming research included the construction of a polynomial algorithm for covering problems that satisfies the integer round-up property.

RICHARD C. LARSON
JEREMY F. SHAPIRO

ROTC Programs

The Reserve Officer Training Corps (ROTC) programs at MIT showed substantial growth during the past year, reflecting the renewed interest in military training which has occurred nationwide. This new vitality of ROTC programs is due to a number of factors, among which are the attractive scholarship programs which are available to many students, a recognition of the value of commissioned military experience, and a lessening of public antipathy toward the military which followed the Viet Nam war. Negotiations are under way at several Boston area universities to reestablish the ROTC programs which were lost in the early 1970s, and these newly established units will in time diminish the number of non-MIT students which enter MIT's ROTC programs via cross-enrollment arrangements. The ROTC Faculty Committee has viewed these cross-enrollments as a good thing for the ROTC programs and for our own students, although the number of non-MIT students using our facilities is monitored to maintain a reasonable balance.

Enrollment in the three ROTC programs at MIT in the fall of 1980 was:

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>YEAR</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Army</td>
<td></td>
<td>48</td>
<td>49</td>
<td>30</td>
<td>27</td>
<td>154*</td>
</tr>
<tr>
<td>Navy</td>
<td></td>
<td>42</td>
<td>45</td>
<td>29</td>
<td>30</td>
<td>146</td>
</tr>
<tr>
<td>Air Force</td>
<td></td>
<td>100</td>
<td>65</td>
<td>38</td>
<td>38</td>
<td>241**</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>190</td>
<td>159</td>
<td>97</td>
<td>95</td>
<td>541</td>
</tr>
</tbody>
</table>

* Within this total are included 69 students cross-enrolled from Wellesley College (7), Tufts University (28), and Harvard University (34).

** Within this total are included 74 students cross-enrolled from Wellesley College (4), Tufts University (8), Harvard University (33), and Northeastern University (29).

Sixty-three seniors, including 50 MIT students, were commissioned on May 31 in a tri-service exercise held at Kresge Auditorium. Antonia H. Chayes of Cambridge, a former Under Secretary of the Air Force, was the principal speaker. The commissioning exercise was preceded on May 8 by a tri-service pass in review in Steinbrenner Stadium, with President Paul E. Gray acting as reviewing officer.
The ROTC Faculty Advisory Committee continued its role in monitoring the ROTC programs and reviewing prospective military ROTC instructors. Although ROTC courses do not receive MIT academic credit, both the MIT faculty and the ROTC staffs insist that the military programs be compatible with MIT standards and procedures, and that the military instructors have the academic credentials to be effective teachers at MIT. All three detachment commanders are retiring at the conclusion of this year, and by next fall Colonel John S. Kark (Army), Colonel Adrian V. Polk (Air Force) and Captain John H. Sweeney III (Navy) will have been replaced respectively by Lieutenant Colonel George S. Smith, Jr., Colonel Joel S. Hetland, and Captain David V. Burke, Jr.

FRANK E. PERKINS

Sea Grant College Program

The National Sea Grant Program was established by Congress in 1966 to support research, education, and advisory services through the nation's university system. The first Federal Sea Grant support was awarded to MIT in 1968 to develop a series of ocean engineering textbooks. In 1970 the Institute officially joined the Sea Grant network as a Coherent Area Program. That event was celebrated during this past year in a 10th-anniversary program that included a special Marine Industry Advisory Service Collegium meeting; an exhibition, "MIT Sea Grant: Ten Years of Ocean Development," mounted by Historical Collections at the Margaret Hutchinson Compton Gallery; the annual Sea Grant Lecture; and an address by President Paul E. Gray at a commemorative luncheon with Sea Grant's friends and participants. President Gray reviewed the highlights of the decade, especially MIT's ascendency to Sea Grant College status, a designation awarded in 1976 by then Secretary of Commerce Elliot Richardson for excellence in research, education, and advisory services. The current director of Sea Grant, Dean A. Horn, hosted the luncheon and introduced the Program's two previous directors, Professor Emeritus Alfred A.H. Keil, and Professor Ira Dyer, Head of the Department of Ocean Engineering.

Later in the day, Professor Dyer moderated the Ninth Annual Sea Grant Lecture. The topic, "Georges Bank: Fish and Fuel," was particularly timely for Massachusetts and the nation, with the impending offshore development of Georges Bank. MIT Sea Grant had been in the forefront of bringing this issue before the public. In 1972 the Program sponsored the first important study of offshore petroleum and New England when Professor John W. Devanney, Department of Ocean Engineering, led an MIT team that looked at the environmental and economic implications of oil development in one of the world's richest fishing grounds. The Program today remains dedicated to seizing the opportunities and easing the problems of offshore development, both in New England and the country.

RESEARCH

A look at Sea Grant's research themes, which help to shape the Program, reveals a current offshore focus. Offshore Facilities and Unmanned Underwater Work Systems are two themes for researching the methods by which offshore work can be conducted more safely and economically.

Offshore Facilities emphasizes the development of technical data and analytical procedures to support the rapid expansion of structures into the offshore environment. The design, construction, placement, monitoring, and maintenance of deepwater structures is an extension and extrapolation of shore-based technology, modified and adapted to maritime industries. During this past year, a Sea Grant project in the Department of Civil Engineering sought to analyze and understand the many factors influencing structural behavior so that an assessment of total risks could be made. A supporting project in the same department developed reliable techniques for measuring sediment properties on site. In cooperation with the government of Venezuela, a research team was able to work at sea to test instrumentation and analytical methodology as part of a major international geological exploration program.
Faculty and students from the Departments of Ocean Engineering, Aeronautics and Astronautics, Electrical Engineering and Computer Science, and Mechanical Engineering have been sponsored by Sea Grant to develop innovative components and systems for operation and control of unmanned underwater work vehicles using the most advanced theories and techniques. They aim to improve human ability to perform complex underwater tasks with remotely controlled telemanipulators. One joint project with the Woods Hole Oceanographic Institution (WHOI) gained substantial industry support. The project applies modern communications theory to encode digital data through frequency-shift keying of acoustic signals. The final result will help to eliminate the need for cumbersome communication tethers between surface ship or platform and the underwater vehicle. A principal requirement of the national Sea Grant Program is that the Federal monies supplied through the National Oceanic and Atmospheric Administration (NOAA) be matched at least one-third by non-Federal funding sources. Industry support, like that supplied by the Gould Corporation to this Sea Grant project, helps meet that requirement and brings the ultimate user of the research into the development process.

Other Sea Grant thematic areas are Coastal Processes, Living Resource Utilization, and Technology Development and Management for Ocean Uses. Projects under Coastal Processes study the interface between ocean and land to anticipate the consequences of human activities in the coastal environment. Living Resource Utilization brings MIT research attention to the improvement of harvesting and processing the ocean's food resources. The broadest of all areas is Technology Development and Management for Ocean Uses. This expansive theme helps to attract faculty members from many disciplines to solve social, economic, environmental, and political, as well as the technological and scientific aspects, of ocean development. This theme area is the primary genesis of the Program's more specific theme areas. As important projects succeed, related projects can be developed and combined into a focused effort. Research in the past year included an assessment of small-scale tidal power in eastern New England, the development of a simple non-destructive test to detect defects in fiberglass boats, and an oil spill liability model that received the joint support of Sea Grant, the oil industry, the Commonwealth of Massachusetts, and several Federal agencies.

During the past year, in response to recommendations from a Sea Grant review committee appointed by the Provost in 1979, the Program expanded the direct participation of the Institute's faculty in managing the Program's research. Three part-time research director positions were established. Professors Keith D. Stolzenbach (Department of Civil Engineering), Anthony J. Sinskey (Department of Nutrition and Food Science), and Chryssostomos Chryssostomidis (Department of Ocean Engineering), are now providing a liaison to MIT's faculty and are helping to manage the research activities of the Sea Grant College Program.

With the new directors' help, the proposal preparation process has been simplified and the review and selection process improved. New guidelines have been prepared and are being formalized in an instruction booklet under the direction of Lawrence W. McKinnon, Sea Grant's administrative officer. Professors Stolzenbach, Sinskey, and Chryssostomidis, and Mr. Horn met several times with the newly established Faculty Sea Grant Committee. Members of the Committee, appointed by the President from throughout the Institute on a rotating membership, provide policy and management guidance to the Program from a strong faculty perspective.

An endowment from the Henry L. and Grace Doherty Charitable Foundation is managed by Sea Grant to encourage non-tenured MIT faculty to focus their research on contemporary problems in the marine field. During their two-year appointments, Doherty professors remain affiliated with their respective academic departments, but conduct their research under the aegis of the MIT Sea Grant Program.

**ADVISORY SERVICES**

The concept of advisory services is one of sharing information and of stimulating communications between the university base of Sea Grant and people working in business, industry, and government, or living in coastal areas. The relevance of the Program's research to the community's needs is dependent upon a continuing, lively interaction among these groups. Throughout the Sea Grant network, each program has designed advisory services to reflect the host institution's strengths, traditional constituencies, and evolving local interests and problems. Sea Grant's advisory services mirror the Institute's preeminence in technology sharing.
The Massachusetts Marine Liaison Service (MMLS), under the management of Arthur B. Clifton, provides a critical connection to constituents in New England and the Commonwealth. During this past year, MMLS helped to introduce to industry a machine developed in the Department of Mechanical Engineering for skinning an abundant and underutilized food resource, the spiny dogfish shark. One of MMLS's staff, a naval architect and graduate from MIT's Department of Ocean Engineering, redesigned a connecting device, originally developed by Sea Grant for the fishing industry, to handle lifeboats on US Coast Guard cutters.

Norman A. Doelling leads the MIT/Marine Industry Advisory Service (MIDAS), a project that has developed a strong working partnership with US government agencies and industries here and abroad. Five workshops this year brought faculty, students, and Sea Grant's constituents in the marine community together to discuss ongoing research, tune it to practical current needs, and suggest further areas of research opportunity. Those workshops included "Measurement and Prediction of Vibration Response of Deepwater Offshore Structures," "Progress in Underwater Telemanipulator Research," "Progress in Controlled Environment Aquaculture and Algae Husbandry," "Oil Spill Clean-up -- An Economic and Regulatory Model," and "The Engineering and Economics of Coal-Fired Ship Propulsion."

Sea Grant's Communications/Information Service provided ready access to information generated through the Sea Grant network, MIT, and by allied marine-related organizations. Headed by Elizabeth T. Harding, the Communications/Information Service publishes a technical and advisory report series, a quarterly bulletin on Sea Grant projects, and a directory of all marine-related research at the Institute. An information specialist manages a small reference facility that keeps archival copies of all MIT reports and pertinent books, pamphlets, periodicals, and reports on subjects that include fisheries, coastal zone management, environmental issues, law of the sea, oil pollution, and offshore development.

EDUCATIONAL EFFORTS

The original mandate in the Sea Grant Act of 1966 called for an education component to be integrated into every program. At MIT this was in harmony with the Institute's own philosophy of training scientists and engineers through research experience and exposure to real problems. Funding for each Sea Grant research project includes support for students, usually at a graduate level. But undergraduates, too, are critical constituents to attract and train for ocean-related careers. In the past academic year Sea Grant established an Undergraduate Research Opportunities Program (UROP) award. Six students were given funds to pursue marine research. The projects were: Public Commuter Transportation Systems in Boston Harbor; Hydrodynamics of Seaborne Uranium Recovery Systems; Cation Exchange Capacities as a Method of Quantifying the Clay Minerology of Marine Sediments; Acoustic Backscattering in the Arctic Ocean; the MIT Deep Seabed Mining Model; Mining Seawater for Uranium; Research and Development of Cooling and Holding Tanks for Long-term Preservation of Freshly Fertilized Eggs; and Comparison of In Situ and Needle Probe Thermal Conductivity Measurement of Deep Ocean Sediments.

This past year, a consortium of Boston area university and colleges, which has conducted a spring introductory course, "Into the Ocean World," incorporated and became self-sufficient following three years of startup support from Sea Grant. Sea Grant continues to support summer session courses for professionals working in the marine field. The education component of Sea Grant is managed by E. Ray Pariser, associate director of Sea Grant and senior lecturer in the Department of Nutrition and Food Science.

Entering its second decade, the MIT Sea Grant Program will, like many Federally sponsored programs, be operating under budget constraints. The program staff believes this to be temporary and that MIT Sea Grant, in collaboration with the Institute's faculty and administration, will continue to provide outstanding service to the Commonwealth, the region, and the nation.

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 67 programs planned for the 1980 session, three were cancelled for projected low enrollments. The total registration of 1,893 in 1980 was a slight increase over the registration of 1,888 in 1979.

Biographical data on the registrants indicated that the characteristics of the 1980 class were remarkably similar to those of 1979. For example, 16 percent of the registrants in both summers came from outside the US and Canada.

Regular Subjects

Graduate students comprise 80 percent of the student body in summer. The 1980 registration of 2,627 students was a small increase over the 2,610 in 1979.

JAMES M. AUSTIN

Technology Adaptation Program

The Technology Adaptation Program (TAP) is an interdisciplinary research program with a primary objective of promoting an awareness of and an expertise in the technological problems facing developing countries on the part of faculty and students at MIT, as well as foreign students and scholars who attend MIT. This objective is met by encouraging faculty participation in specific, well-defined research projects with faculty collaborators from academic institutions in certain developing countries. In addition to the research projects, TAP has conducted a wide range of academic activities including: development of informal institutional ties between MIT and foreign universities, research institutions, and government organizations in developing countries; educational opportunities at MIT for those interested in issues of technology and development, such as interdisciplinary master's degree programs, graduate research assistantships, and visits by foreign scholars; conferences, workshops and seminars; and dissemination of information through publication of technical reports, working papers, and proceedings of its conferences.

ORGANIZATION

The Technology Adaptation Program is organized according to the following principles:

1) The program relates to those research activities for which there exists faculty support and faculty willingness to participate. The program does not undertake research projects which require large-scale non-faculty staffing. The research activities are supervised and conducted by faculty members, and are administered through their respective home departments.
2) The program committees are composed of MIT faculty members, and the program director is a faculty member, thus maintaining academic quality control not only in the conduct of research and educational obligations, but also in the selection of topics for research and the institutions with which the program develops educational ties.

3) The program's activities are carefully scrutinized by appropriate Institute committees such as the Committee on International Institutional Commitments. The Institute is consulted in the early stages of negotiation on all potential sources of funding, including public and private sources both in the US and abroad.

The Technology Adaptation Program is organized with the following basic components:

- The program director, Professor Fred Moavenzadeh of the Department of Civil Engineering, is responsible for the coordination of all resources utilized for the program.

- The TAP Policy Committee is chaired by Professor Nazli Choucri of the Department of Political Science who is also associate director of the program. Committee members are Professor Daniel M. Holland of the Sloan School of Management and Professor Jack Ruina of the Department of Electrical Engineering. Professor Moavenzadeh serves in an ex officio capacity.

- The TAP Advisory Committee, composed of the Deans of the Schools and chaired by the Provost, is responsible for overseeing TAP activities and advising on Institute policies and administrative procedures. Professors Choucri and Moavenzadeh serve as ex officio members.

Jeanne De Pass is the program's administrative officer and Kevin O'Toole serves as technical officer. James H. McCarthy served as the resident administrative officer of the MIT/Cairo University Liaison Office in Cairo.

TECHNOLOGICAL PLANNING PROGRAM IN EGYPT

In December 1976 the US Agency for International Development (AID) entered into a contract with MIT 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 programs, and to study the feasibility of institutionalizing the process by establishing a Research Center at Cairo University. The means by which the general objectives are pursued is through cooperation with the faculty of Cairo University in developing capabilities to contribute to the formulation and implementation of science and technology-related policies designed to assist Egypt's developmental goals. To this end, three specific objectives have been pursued: 1) mobilization of academic interest in research on specific development plans; 2) organization of technical research in collaboration with Egyptian government ministries; and 3) establishment of an institutional framework in Egypt through which permanent research and training capability can be organized.

The specific research projects organized so far employ three general analytic approaches: 1) engineering analysis and technical project evaluation, addressing specifically technical issues, including field and laboratory studies, design, 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, technology transfer, and strategies.

Since 1976, 15 collaborative projects have been developed between MIT faculty members and their counterparts at Cairo University and the appropriate ministry or government agencies in Egypt. They focus on a broad range of engineering, economic, and social science topics, as described below. The key element in each of these efforts is the interdisciplinary team drawn from faculty and staff from MIT, Cairo University, and government resources, and 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, management, and the development and maintenance of the data necessary to design and monitor their projects.
The total expenditures on this program to date have been $11.5 million, and a new contract signed in October 1980 provides an additional $12 million over the next three years. The largest expenditure of funds at MIT has been for student support (26 percent) followed by faculty support (19 percent). The interdisciplinary nature of the program is demonstrated by the distribution of funds within the School of Engineering (56 percent), the School of Humanities and Social Science (25 percent) and the School of Architecture and Planning (19 percent). Projects which will involve the School of Science and the Sloan School of Management have been approved for the coming year. This expands to nine the involvement of departments within all five Schools of the Institute.

RESEARCH PROJECTS

The research projects have focused principally in four broad areas: 1) energy, including electricity generation and distribution, and Egyptian oil resources, including production processes and consumption; 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 from mathematical economics and operations research to analyze project alternatives for Egyptians concerned with planning electric power projects. This project is under the direction of Professors Martin Weitzman (Department of Economics) and James Kirtley (Department of Electrical Engineering and Computer Science). Dr. David Woodruff assists in this project.

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

Manufacturing

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

Public Works

*Housing and Construction Industry.* The objective of this project is to develop the technical and economic knowledge and tools needed in the determination of national housing policies. Specific recommendations are intended to be developed with focus on investment policies, controls, and regulations, and 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 under the direction of Professor N. John Habraken (Head, Department of Architecture). Professors Albert G.H. Dietz, Eric Dluhosch, and Edward Allen (Department of Architecture) are also participating in this project.
Intercity Transportation Planning. The objective of this project is to develop a methodology that will make possible the systematic analysis of future transportation investment policy proposals in Egypt. The methodology, which addresses both intercity freight and passenger movements on highways, railways, and inland waterways, will complement previous transportation planning efforts in Egypt. This program is under the direction of Professor Moavenzadeh. Research associates Michael J. Markow, Brian Brademeyer, and Frederick Salvucci in the Department of Civil Engineering are contributing to this project.

Urban Transportation. The objective of this project is to assist the Transport Planning Authority and other agencies to strengthen their project implementation and policy-making processes in the area of urban transportation. This project is under the direction of Professors Nigel Wilson and Michael Meyer (Department of Civil Engineering). Professor Ralph A. Gakenheimer (Department of Urban Studies and Planning) continued his interest and contributions to this project.

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 a storage reservoir, and their interaction with irrigation and drainage activities. This project is under the direction of Professor John L. Wilson (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 the water resources 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 under the direction of Professors Rafael Bras and Peter S. Eagleson (Department of Civil Engineering).

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

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

Socioeconomic Development

Communications Needs for Rural Development. The objective of this project is to assess the needs of Egyptian villages for communications technologies in order to improve the economy and society of the villages. This program is under the direction of Professor Ithiel de Sola Pool (Department of Political Science).

Egyptian Labor Migration. The objective of this project is to contribute to an understanding of the costs and benefits to Egypt of the migration of labor to other Arab countries. Toward this end, 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 will also be visible. This project is under the direction of Professor Choucri.

DEVELOPMENT RESEARCH AND TECHNOLOGICAL PLANNING CENTER AT CAIRO UNIVERSITY

As part of the institutional efforts of the program in Egypt, MIT provided assistance and support aimed at establishing a permanent institutional mechanism to facilitate and promote academic research directed toward developmental goals of Egypt. In early 1979 the Development Research and Technological Planning Center (DRTPC) was established, and a director and a board of directors were appointed.
Technology Adaptation Program

In November 1980, with 18 months of experience in the operation of the Center, it appeared timely to review its organizational structure and its interrelationship with the goals and objectives of the Cairo University/MIT Technological Planning Program. A meeting was held at MIT with the objective to establish specific direction of the new phase of the program with particular attention to institutionalization. Three distinct elements of the Center's organization were addressed: the policy-making bodies, the administrative infrastructure, and the operation of the research. The board of directors of the Center constitute the policy-making authority. Their roles and functions have been defined and the membership has been changed to include the Cairo University Executive Committee with the Rector of Cairo University as chairman. Under the reorganization, the nature of the administrative infrastructure is broad and requires a position at an executive officer level for its administration. This position, which has been filled, is responsible for the day-to-day activities of the Center. The new contract requires greater emphasis on expanding the base of participation of Cairo University faculty members and of interested government ministries. A sharper focus has been given to the research operation, its direction, and management in order to facilitate contacts between faculty members and ministry personnel.

EDUCATIONAL OPPORTUNITIES

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

Some of the more specific educational opportunities offered during the past year include those outlined below.

Research Assistantships. The number of graduate research assistantships offered by the program has shown a steady growth since the initiation of the program in 1976. To date, 128 research assistantships have been in effect. Twenty theses, eight at the Ph.D. level, have resulted from these assistantships, with an additional 32 in progress, 18 at the Ph.D. level.

Visits by Foreign Scholars. To date over 150 Egyptian participants from Cairo University and various government agencies have visited MIT. Some have attended short courses on specific topics, while others have followed more informal programs designed to increase their awareness of current developments in their fields. During their visits to the Institute, most of them also have performed work on the specific research projects in collaboration with their MIT counterparts. In addition, several have had the opportunity to meet with other MIT staff members interested in similar problems of technology adaptation and development.

Travel by MIT Staff. MIT faculty, staff, and students spent a total of four person-years in Egypt during the past year. Several staff members were also able to visit other locations overseas to meet with experts working on similar development problems, or to attend conferences relevant to project research. In addition to the TAP research and administrative staff, James Culliton, director of Personnel, and Robert J. Long of the Comptroller's Accounting Office, travelled to Cairo to assist in the operation of the Liaison Office.

Conferences, Workshops, and Seminars

The program normally holds at least one major conference in Cairo each year. By so doing the participants have the opportunity to present the results of their research efforts to their peers and to those personnel working in the field, primarily from the government ministries, who may not be aware of the state-of-the-art research being conducted in Cairo.
In the past year a major conference was held in January at Cairo University. It presented an opportunity for all principal investigators to discuss the technical aspects of their projects. Also in January, the Second International Conference on Water Resource Planning in Egypt was held. Seven technical sessions were held and papers on the Egyptian Water Master Plan, Surface Water Hydrology, Water Quality, and Groundwater Hydrology were discussed. Of the 27 technical papers which were discussed, five were presented by MIT graduate students. Associate Provost Frank Perkins delivered the keynote address at the conference, which was attended by over 250 people. Following the Water Resources Conference, a workshop on the Management of the Nile Delta Groundwater Aquifer was held and attended by 80 people. Newly recognized upward leakage of the groundwater in the delta has caused concern within the Egyptian Drainage Research Institute and this workshop was held to present the findings, and to discuss the impact and available alternatives. Provost Francis Low visited Cairo during this period to familiarize himself with the technical and administrative aspects of the program.

In March of 1981 the Plastics Project held a seminar for 100 attendees. The research group presented their findings to business and government personnel from Egypt in order to encourage local industry to invest in pipe production facilities.

NEW INITIATIVES OF THE CAIRO UNIVERSITY/MIT PROGRAM

During the new phase of the program a series of initiatives has been added to the efforts of the collaboration. These initiatives are in addition to the research project concept which proved effective in the past and include the following:

1) Undertake a series of mini-research projects of three to six months duration with emphasis on increasing Cairo University capabilities, which can lead to the development of long-term contracts with government ministries.

2) Provide support to junior faculty members at Cairo University in postdoctoral research. This effort will involve course work at MIT and associations with MIT faculty members.

3) Provide financial incentives for graduate student theses in areas of relevance to the development goals of Egypt.

4) MIT faculty participation in course development at Cairo University.

5) Development of short course "packages" to be offered to ministry and Cairo University personnel.

6) Establishment of mid-career educational programs for ministry personnel.

7) Establishment of mid-career educational programs for Cairo University faculty members.

8) Provide laboratory equipment to Cairo University departments.

In June 1981 the joint committees reviewed and approved the awarding of the first set of doctoral and postdoctoral fellowships and Ministry internships. Within this set, 13 postdoctoral fellowships, 10 doctoral, and seven internships have commenced. They include researchers from the Cairo University faculties of Engineering, Science, Economics and Political Science, and Commerce. These programs will involve some MIT faculty members to assist and direct the research, as well as a limited involvement of the Egyptians in educational opportunities at MIT.

TAP publishes its own series of technical reports in addition to those papers which are included in the broader area of the principal investigators' technical journals. Since the start of the Egypt project, over 250 papers and reports have been published.

FRED MOAVENZADEH
Undergraduate Research Opportunities Program

We have become acutely aware over the past 18 months of increasing demand upon our resources. For the summer of 1980 and the 1980-81 academic year, we increased the Undergraduate Research Opportunities Program's (UROP) minimum rate to $4.50 an hour in an effort to respond to the growing financial pressures on our students. (Compared to the $2.50 per hour rate we offered in 1972, UROP has only just managed to stay abreast of inflation.) During the academic year the demand continued high. In past years students seeking UROP wages during term time comprised less than one-third of those seeking UROP credit or working as research volunteers, or less than one-quarter of all UROPers. This past academic year there was a 40 percent increase in UROP wages requests. Much of the response to the increased need was carried by the sponsored research contracts of faculty members: approximately $1.1 million (as compared to $83,630 in fiscal year 1974). UROP students comprise the largest earning category of undergraduate employment at MIT.

Ten years ago, in February of 1971, we surveyed the MIT undergraduate student body with a questionnaire distributed to some 225 known UROP participants and to another 450 randomly selected undergraduates. That survey's objective was to illuminate the areas in which UROP was meeting or not meeting its objectives after one and one-half years of operation. This past spring, using a slightly updated version of the same questionnaire, we comparison surveyed 450 known UROP participants and another 450 randomly selected undergraduates. A return rate of 60 percent was observed for the UROPers and 38 percent for the random sample. We hope to have a full analysis ready in the fall.

Preliminary analysis of the raw data indicates that 68 percent of the students currently involved in undergraduate research initially became involved as early as their freshman or sophomore years. Three-quarters of students involved in research have worked at least two semesters in research, averaging 10 hours per week during the term. Of all participants, 83 percent have utilized the Independent Activities Period (IAP) and/or summer for more concentrated involvement. The majority of students receiving credit earn between nine and 14 units of credit for their research, generally as elective credits satisfying no Institute or degree requirements.

There is a striking similarity in the 1971 questionnaire and the 1981 questionnaire results in the area of the "most significant gains" students feel they derive from their research. Highest on their lists, both 10 years ago and now, are the following: 1) the importance of personal contacts with professors and other professional members of the MIT community*; 2) the opportunity to be introduced to an interesting field; 3) the gaining of professional experience; and 4) the chance to learn technical skills. In addition, most students laid claim to a tangible result of their research: a research paper, a recommendation for graduate school or permanent employment, or a thesis.

When asked, "Would you have joined this research project if you had known the costs and benefits?" 93 percent replied "Yes." We invited comment at the end of our questionnaire regarding "... elements in the undergraduate program, the MIT atmosphere, the pace of undergraduate life, your own technical background and skills, or whatever else (which) may have either helped or hindered your involvement in undergraduate research." The category of comment we saw time and time again with regard to hindrances to involvement was "the fast pace of MIT." Students indicate overcommitment not only in their course load, but in extracurricular and social activities. UROP is only one among many possible time commitments tugging at them. At the same time, and occasionally as part of the same response, we were told how often UROP figured crucially into individual decisions to attend MIT rather than another college.

* It is interesting to note that the personal identifications that students make with their immediate research groups appear to override their identification with any particular larger laboratory or department (e.g., the "Space Systems Lab" as compared to the Department of Aeronautics and Astronautics).
Close interaction with other MIT offices, departments, laboratories, and programs has always provided the map for charting our course. Long-held discussions with sponsors of the Undergraduate Seminar Program, concerning possible ways UROP might make a contribution that would strengthen and enhance the program, now hold promise for the collaboration of UROP with the Undergraduate Academic Support Office (UASO) in the coming year. The ongoing curriculum review by the Committee on Educational Policy (CEP) has engaged UROP at several junctures: writing proficiency, the Institute Laboratory Requirement, and the pace and coherence of the MIT undergraduate program. As this review progresses, UROP will be in close contact with the CEP and with the UASO. The Alumni Office called upon us again to present a program with undergraduate researchers, this time to the Fairfield County Alumni Club. The Resource Development Office has invited UROP to participate next year at the Corporation Development Committee's full meeting. MIT students were invited by television channel 56 to comprise a half-hour panel program entitled The Cambridge Forum. (This was our second Forum; the first was on public radio.) UROP staff members currently serve on the CEP; on the Clapp and Poliak Engineering Design Award Committee; on the Eloranta Summer Fellowship Award Committee; on the IAP Coordination and Policy Committee; on the Student Wage Rate Study Committee; as consultants to Brown University in evaluating the University Internship Program; as Freshman Advisors; as leader of an Undergraduate Seminar; and as "friends" of particular IAP, Residence/Orientation, Freshman Council, and Student Society of Women Engineers activities.

We continue to have interaction with other colleges and universities which have established undergraduate research programs based directly on, or modeled after, MIT's UROP: e.g., Imperial College, London; Utah State University; University of Delaware; and Johns Hopkins, Stanford, and Harvard universities. In addition, this year brought substantive interaction with the Department of Education, the Sloan Foundation, the National Science Foundation, UNESCO, and the National Academy of Sciences, concerning science and engineering education and educational innovation.

NORMA MCGAVERN
MARGARET MACVICAR

**Upward Bound Program**

The MIT-Wellesley Upward Bound program is a coeducational, multiracial, multietnic educational program for Cambridge high-school aged youth. Now in its fourteenth 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 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 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
Upward Bound Program

are team-taught by experienced high school teachers, students from Wellesley College and MIT, 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 English, film studies, religion and world views, US history, social psychology, and cultural identity in America. Science courses include biology, physics, human physiology, computers, and chemistry, and are supported in part by a grant from IBM. 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 MIT and Wellesley undergraduates, have been developed and implemented.

Study Skills

The MIT Upward Bound offices are open for study five afternoons a week from 3:00 to 7:00 pm and one evening per week from 7:00 to 9:00 pm. Students are asked to spend at least one afternoon or evening per week at one of the 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 MIT or Wellesley College undergraduates who meet regularly on a mutually convenient basis with the Upward Bound student and then report back to the staff. During the past year, space was made available for meetings and tutoring in the Cambridge Rindge and Latin 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 once a month for six hours. The Saturday program includes arts and crafts, drama, and the use of the pool and gym, as well as other extracurricular activities.

College Report, Class of 1981

Graduating seniors have been placed in colleges as follows: Boston State College, Boston University, Dean Junior College, East Coast Aero Tech, Fitchburg State College, Florida A and M, Georgetown University, Johnson C. Smith University, Maine Central Institute, Norfolk State University, North Bennett Street Industrial School, St. Augustine's College, Wellesley College, Westfield State College, and Winston-Salem State University.

We are looking forward to a renewed commitment under the new directorship of Ronald S. Crichlow.

RONALD CRICHLOW
Project STILE

Under the auspices of Institute Seminars 211 and 212, local opportunities are available for students to become involved in a rather wide range of educational action research and/or community service activities, as well as obtaining Massachusetts Teacher Certification. Research and service opportunities are made available through Project STILE (Student-Teacher Interactive Learning Environment) and Upward Bound, both sponsored through the Seminars, and Massachusetts Teacher Certification through a joint program with Wellesley College.

THE PROGRAM

Project STILE, drawing from the experience of its staff with the MIT/Wellesley Upward Bound Program and based on Dr. Robert Rosenthal's pioneering research on expectations and the self-fulfilling prophecy, is an in-service teacher training program that works to improve the learning environment by demonstrating how teachers' expectations have a powerful effect on student achievement.

The STILE approach has been collaboratively developed at the Institute by MIT staff and Cambridge teachers since 1977, under the auspices of the Massachusetts Department of Education Title IV-C funding for innovative programs. The major objective of Project STILE is to train teachers to interact more effectively in the classroom, particularly with students who have a history of poor classroom performance. The project is based on the premise that the pattern of academic disengagement among these students, who constitute a sizable segment of many urban classrooms, can be explained, at least in part, by the inequalities in the student-teacher interactions in the classroom. Teachers often have low expectations regarding the academic achievement of their disengaged students; and these expectations, when reinforced by the classroom behavior of the students themselves, tend to create a vicious cycle of low expectancy-low involvement-poor performance, which may eventuate in dropping out of school. STILE, which was validated in 1979 for state-wide dissemination as an exemplary educational program by the Massachusetts Department of Education, offers ways of breaking this cycle by raising teacher expectations for all students.

Cambridge

The Cambridge Rindge and Latin School has made Project STILE its number one staff development priority, and has created the full-time teacher-in-charge position of "In-School Project Assistant" at the high school to facilitate Cambridge's takeover of the Project and to improve communication and organization. Cambridge teachers, trained in leadership roles, worked with MIT staff to bring STILE to other school systems in Massachusetts.

Other Interventions

Three successful interventions took place this past year in Chelmsford, Somerville, and Boston. Despite the fact that Proposition 2 1/2 placed many of the participating teachers' jobs in jeopardy, the Project was received with much interest and enthusiasm. Efforts to continue STILE next year are being made on the part of these participants.

Parent Component

In the summer of 1980, the Cambridge School Department received a Title II Basic Skills National Demonstration Grant, which was primarily designated to introduce STILE into the elementary
schools. Two target schools were chosen in areas where strong lower-socioeconomic groups existed. With this grant, STILE introduced a component which involved parents in workshops modeled closely after those offered to teachers in an effort to bridge the gap between home and school. The purpose of the STILE parent workshop was to familiarize parents with the research and ideas about expectations, and to develop in them a greater awareness of their potential role in raising expectations for their own children as well as for others. These parents will participate with a group of teachers from the target schools in a two-week workshop during the summer of 1981, where they will become competent in STILE techniques and will develop a plan for involving teachers and parents as teams in the schools next fall.

Seminars

Institute Seminars 211 A Practicum in the Role of Education in Society and 212 A Reading Course in the Role of Education in Society are part of a joint program with Wellesley College enabling MIT and Wellesley students to obtain teacher certification for Massachusetts. Seminar 212 is included in the list of humanities distribution subjects, and Seminar 211 uses Upward Bound as a field placement. SRE 222 The Social Psychology of Schools offers graduate students the opportunity to explore the social psychological theory of expectancy, the effects of this theory, and how expectations are communicated.

JOHN P. TERRY

Wellesley-MIT Exchange Program

In the thirteenth year of MIT's Exchange Program with Wellesley College, cross-registrations of individual students continues to be the main activity of the Exchange. During the 1980-81 academic year, Wellesley students enrolled in 230 MIT subjects in the fall term and 271 subjects in the spring term, while MIT students took 114 Wellesley subjects in the fall term and 217 subjects in the spring term. These enrollments are comparable to previous years.

To help balance cross-registration, Wellesley again offered Religion 108 Introduction to Asian Religions on MIT's campus during the second semester. One of the Wellesley subjects most popular with MIT students, Religion 108 was among the seven Wellesley subjects approved to fulfill the MIT Humanities Distribution Requirement this past academic year. Also in the second term, an MIT Political Science subject, 17.401 Aggression, War and Civilization held half of its class meetings at MIT and half at Wellesley, thereby attracting a larger Wellesley enrollment.

In addition, Wellesley and MIT faculty and students interact through the Cambridge Humanities Seminar and the Center for Materials Research in Archaeology and Ethnology (CMRAE). Student enrollments in these programs' offerings are not always included in the cross-registration statistics because the subjects often have course numbers at both institutions. For example, CMRAE's seminar on analysis of materials is called Anthropology 308 for Wellesley students and 21.544 for MIT students. This year it was taught by Professor Wilma E. Wetterstrom, an MIT faculty member, and held at Wellesley during the first semester and at MIT during the second semester.

During the spring term two MIT seniors and a junior lived in a Wellesley dormitory. This is the first time MIT students have been in residence at Wellesley during a regular semester since the residence exchange was discontinued in 1972. If space permits, Wellesley plans to offer dormitory rooms to MIT students again next year.

With a new administration at MIT this past year and a new President, Nannerl O. Keohane, assuming office at Wellesley on July 1, 1981, the Provost of MIT, Francis E. Low, and the Dean of Wellesley College, Maud H. Chaplin, agreed that it was time for an evaluation of the Exchange and recommendations for its future. Therefore, an ad hoc Wellesley-MIT Exchange Review Committee was established, with three faculty members representing each institution: from MIT, Professors Irene Tayler (co-chairperson), Frederic R. Morgenthaler, and Robert J. Silbey; from Wellesley, Professors
Elizabeth Rock (co-chairperson), Barry Lydgate, and Susan S. Silbey. Frank E. Perkins, Associate Provost of MIT, and Dean Chaplin are ex officio members of the committee. Mary Z. Enterline, MIT Manager of the Exchange, and Dorothy Moeller, Wellesley Coordinator of the Exchange, serve as staff to the committee. During the spring semester, committee members conducted surveys at the two schools, and they are currently in the process of writing a report for presentation next September.

While the program is under review, the Wellesley-MIT Joint Committee continues to function, but under new leadership. Kenneth M. Hoffman, professor of Mathematics, who served as MIT co-chairperson since 1974, resigned from the Joint Committee at the end of the 1979-80 academic year. His contributions to the Exchange were innumerable as he strived, in his own words, "to make the Exchange work." Professor Hoffman has been succeeded as co-chairperson on an interim basis by Louis Menand III, Special Assistant to the Provost. At Wellesley, where the co-chairmanship of the Joint Committee rests with the Dean of the College, the post changed hands temporarily in the middle of the academic year as Dean Chaplin became Acting President for six months, and Edward A. Stettner, Associate Dean of the College, became acting dean. Other members of the 1980-81 Joint Committee were, from MIT, Professor Claude R. Canizares, Ms. Enterline, Dean Holliday C. Heine, Nicholas Kojey, Professor Perkins, Professor Joseph M. Sussman, Professor Tayler, Dr. John P. Terry, Jeffrey C. Tung, and Professor James H. Williams, Jr., and, from Wellesley, Professor Lorraine E. Ben-Ur, Barbara Farquhar (adjunct), Professor Marshall Goldman, Dr. Carol Johnson Johns, Professor Nancy Kolodny, Dean Florence Ladd, Ms. Moeller (adjunct), Helen M. Morrison, and Arlene Rozzelle.

Personnel in the MIT Exchange Office also changed during this past year. Jane L. Sauer, who had administered the Exchange since its inception, resigned as the MIT Exchange Coordinator at the end of the 1979-80 academic year. Also leaving at that time was Joel Orlen, executive officer in the Provost's Office, who had supervised the Exchange for the Provost's Office. With their departures, a new position, Manager of the Wellesley-MIT Exchange and Independent Activities Period (IAP), was created and Ms. Enterline, editor of the IAP Guides and a Wellesley alumna, was appointed to it. In August, Donna Lee Kennedy was hired as MIT Coordinator of the Exchange and Angela M. Price as senior office assistant. Ms. Kennedy left the Coordinator's position in June, and the office staff is currently being restructured.

MARY Z. ENTERLINE
In the face of the nationally diminishing pool of prospective students, applications to the School of Architecture and Planning continue to be strong, a response to the School's enduring position in architecture and planning education. In the Beaux-Arts days, the School brought in Alvar Aalto; through the 1960s and 1970s, the School incorporated humanistic and societal approaches into its teaching. Today it is noted for its view of professionalism as the opportunity to create frames for action by others that are more socially and personally satisfying than could be possible without the professional's intervention.

In recent years, the School has taken the lead on accreditation issues; it has sponsored important conferences on energy and education; it is in the forefront of international exchange; it is expanding into a new arena of professional concern in arts and media technology. Moreover, through these and other activities, the School is also in the forefront of developing types of research which can become as integral to practice as they are necessary to education.

RESEARCH

Approximately $3 million of research is now going on in the School, much of it administered and stimulated by the School's Laboratory of Architecture and Planning (LAP). Research has already informed course content, curricular structure, student careers and experience, and knowledge of practice.

The School's publications programs, which comprise more than 50 titles, provide national distribution for reports produced through research projects, and its special education program provides opportunities for researchers to present their work through continuing education courses, symposia, and special institutes. Researchers have also developed a number of collaborative ventures with researchers in other universities and government.

While the practice aspects of architecture and planning continue to be important, research connections to emerging intellectual fields help attract the best faculty and students and help maintain an energetic link between education and societal problems. Additionally, sponsored research increasingly provides major and much-needed financial support for students and faculty. It is vital to maintaining the student financial aid that insures a diverse student body.

As research activities increase, the School is better able to respond to new areas of research created by sponsors outside the Institute. With a cadre of students looking for research opportunities, and with a faculty who have students available to do research and who can join with faculty members and students in similar patterns from elsewhere in the Institute, the School should be able more readily than in the past to respond to and be successful in obtaining research grants and contracts.

International

The international engagements of the School and their relation to educational and professional goals are also an important factor in the reach and influence of the School. These include the Special Program in Urban and Regional Studies (SPURS); the Technology Adaptation Program (TAP) for Egypt; the International Laboratory of Architecture and Urban Design at Urbino, Italy; the Aga Khan Program in Islamic Architecture; and teaching and exchange activities in South America, Japan, and China.
The School is an active participant in the Institute's efforts to launch collaborative research and education programs with the University of Tokyo. This year it reached initial agreements about strategies for collaboration with counterparts in the departments of architecture and planning. The LAP is coordinating the School's collaborative energy research with the Technical University of Berlin and will host a delegation of architecture faculty and students in the fall of 1981. In addition, a working relationship with the International Center for the Study and the Restoration of Cultural Property (ICCROM) was formalized to launch a program of collaborative research.

The School managed three special international programs in the past year. One was the MIT day in the "Great Cities of the World Conference," the event that climaxed the "Boston 350 Celebration." The School made three major presentations to 300 international visitors about how city form and plans evolve to reflect their cultural context. Panel participants in the MIT day were the mayors or their representatives of Nairobi, Hong Kong, Dublin, Hangchou, Rome, and Montreal.

Two symposia brought together academicians and practitioners to frame and launch longer-term international research efforts. The symposium, "Assumptions Underlying Major Schools of Planning Thought," brought together academicians and practitioners from the United States and France to begin a series of meetings to be carried out over the next few years. Another symposium, entitled "Housing and Human Settlements: Looking Ahead into the Eighties," brought together invited participants representing Brazil, Mexico, Venezuela, and Argentina. The focus of this meeting was the exploration of new approaches to the many problems facing nations of Latin America and the US in planning, finance, management, and technology utilization in the fields of housing and human settlements.

The Visiting Committee

The Visiting Committee spent two days in October 1980, exploring the programs of both departments. A decade ago the issue of field-based learning focused the School's educational concerns and was the theme of a Visiting Committee meeting. This year research was chosen similarly to illuminate educational challenges and opportunities that cross academic boundaries.

Seventeen members (out of 23) examined the role of research in both supporting and leading education in the School and addressed the critical questions of resources -- faculty, staff, money, space -- needed to sustain the School's growing research agenda. Members defined several problems that emerge from the School's efforts to create new and effective directions for professional education, which combine practice and research. These include lack of established research tradition and the need for new role models and traditions; lack of or unsteady sources of funding; lack of adequate graduate student funding to insure both the diversity and number of students; and lack of appropriate and appropriately located space.

The Committee urged the Institute to consider ways of improving time and financial incentives for research, including periodic review of the terms of employment of individual faculty members according to the nature of their speciality, and some greater latitude in the use of available internal funds. To insure reliable funding, in addition to the coordinating and support role of the LAP, there needs to be greater coordination and support across all levels of the Institute. The Committee also urged the Institute to temper its view of student aid for the School with the reality of lower salary expectations for our students than their counterparts in, for instance, business and engineering.

The Committee commended the administration's support of studio refurbishment and the improvement of spaces provided for the Visible Language Workshop and the Film Theatre. Despite this encouraging attention under the new administration, more fundamental help is needed to provide, for instance, a center and expanded space for the Department of Urban Studies and Planning (DUSP), and enlarged and improved space for the Rotch Library.

In conclusion, the Committee commended the School's diversity of learning opportunities; the School's attempt to provide for international projects and to establish new links with the private sector; and the School's experiments to link practical learning and teaching via research. The Committee observed that the professions have responsibilities to change and that the School seems on the way to finding a newly responsive professional model based on research and practice.
Community

Two School projects are particularly related to the School's involvement with local concerns. In January 1981, after a year of planning and a year of development, the Boston Neighborhood Network was established as a nonprofit community organization. The Network is an innovative project that attempts to make university-based research useful to the leadership of neighborhood organizations. It presents workshops, seminars, and conferences about diverse subjects, such as mortgage lending patterns, use of appropriate technology, and social indicators as a tool for guiding neighborhood development. MIT continues to participate as a strong contributor. Additionally, an Impact 2 program, directed by MIT for an inter-university consortium, monitors the long-term impact of the state-wide program of tax and spending reduction authorized by Referendum Proposition 2\(\frac{1}{2}\), passed in November 1980.

Publications/Communications

The School's public image is increasingly evident to a broad public as well as professional audience. Several major publications appeared during the year; others progressed through the planning stage. School members were also involved in planning an important new film series.

A special issue of Plan magazine reviewed the past two decades of the School through interviews with selected faculty members. A forthcoming companion issue is intended to examine the School's development through interviews with selected alumni. Impact: 2\(\frac{1}{2}\) appeared as a regularly published clearinghouse of information on the impact of Proposition 2\(\frac{1}{2}\) for citizens and public officials. The Environmental Impact Assessment Review, a quarterly journal, is in its second year of publication; Positive, the annual publication by graduate students in photography, continued into its second year. We are currently well along in planning a quarterly design journal jointly sponsored by our School and the Berkeley College of Environmental Design; Professor Julian Beinart has assumed editorial responsibility for an annual American edition of Spazio e Societe.

The Department of Architecture published The Grunsfeld Variations: A report on the thematic development of an urban tissue. A team of faculty and students contributed to this publication, which documents their design explorations of a design project at the scale of interrelations that is smaller than the urban structure and larger than the single building.

Two volumes of the Architecture Education Study were completed. It was funded by the Andrew W. Mellon Foundation and directed by Dean William L. Porter of MIT and Professor Maurice Kilbridge of Harvard Graduate School of Design on behalf of a consortium of East Coast schools of architecture. One volume contains case studies of studio teaching; the companion volume contains interpretative essays based on the case studies. These volumes will be distributed to the Foundation, the study participants, and American schools of architecture.

Several members of the School serve on the advisory board for a series of five one-hour programs on American architecture and design to be produced for national public television. In another vein, the School has begun an exploratory effort to define a longer-term examination of the impact of telecommunications technology on settlement patterns.

Among many individual publishing and communications efforts, Professor David Birch authored a study on the job generation process, which received the 1980 Small Business Administration's Research Advocate of the Year Award. Research Affiliate Thomas Piper was awarded an ACE (cable TV equivalent of the EMMY) for a public affairs documentary produced for cable television.

Degree Programs and Admissions

In the past year there were 887 applications submitted for September 1981 admission to the graduate programs in the School. In the Department of Architecture, the M.Arch. program received 289 applications, of which 39 were offered admission and 25 have accepted (to date). There were also 17 applications for continuing graduate study from the Department's undergraduate programs, with 13 being offered admission and 11 accepting. In the other graduate programs, admissions have gone as follows: S.M. Arch S. -- 158 applications, 45 offers, 33 acceptances; S.M. Vis. S. -- 74 applications, 19 offers, 15 acceptances; Ph.D. -- 23 applications, eight offers, five acceptances.
The M.C.P. program in the Department of Urban Studies and Planning received 250 applications, of which 52 were offered admission and 48 accepted. Seventy-six students applied to the Ph.D. program, with 26 being offered admission and 19 accepting. In the Department's special non-degree programs, SPURS and the Community Fellows Program (CFP), 29 people have been invited to participate in 1981-82: 23 for SPURS (out of 55 applications), and six for the CFP (from 23 applications). So far, SPURS has 14 acceptances and the CFP, six.


School Administration

The MIT School of Architecture and Planning is undergoing a significant administrative transition. Jean P. deMonchaux, an architect and planner from Australia, will assume the position of Dean on September 1, 1981; William L. Porter, Dean of the School since 1971, will be on sabbatical in the coming academic year and then return to the faculty of the School.

There are also imminent changes in the positions of head of both departments. Professor John Habraken is stepping down as Head of the Department of Architecture in the fall and Professor Lawrence Susskind as Head of the Department of Urban Studies and Planning the following fall. Searches are under way to fill both positions. Julian Beinart will serve as Interim Head of the Department of Architecture. In that capacity, Professor Beinart will direct a major effort in establishing a long-range departmental agenda.

WILLIAM L. PORTER
# STUDENT ENROLLMENT AND COMPOSITION 1980-81

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* 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 (CFP), established in 1971.

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Department of Architecture

The Department's diverse structure is reflected in this report by separate sections on the five degree programs.

This year brought further consolidation of the new S.M. Architecture Studies program. With this program in place its complementary relation with the M.Arch. program needs to be structured further. The unique potential of this relationship for the study of architecture begins to emerge and needs careful cultivation.

Planning continued for a new Arts and Media Technology entity into which the existing S.M. Visual Studies degree program might be incorporated. The effort brings up the question of the arts in relation to research and in relation to MIT undergraduate education. These crucial questions need to be addressed more directly, as they go beyond the Departmental scope.

The Aga Khan Program for studies in Islamic Architecture and Urbanism began to establish itself within the Department with the completion of spaces for staff, students, and library, as well as with the beginning of an academic program. There was a well-attended lecture series with an international roster of speakers and a summer subject that attracted broad professional interest.

Overall enrollment figures within the Department are encouraging. The Master of Architecture program seems to stay in a fairly steady state with eight to nine times the number of applications as there are places for students. The S. M. Architecture Studies program saw an increase in enrollment, as planned, as well as an even stronger increase in number of applications. The S. M. Visual Studies program, made up of the Visible Language Workshop (VLW), Film/Video, Photography, Center for Advanced Visual Studies, and the Architecture Machine, showed the greatest proportional increase in enrollment. The Ph.D. program continued to attract applications from highly qualified candidates. Undergraduate program enrollment figures, which had been decreasing for many years, appear to have leveled off.

Lack of funding for student support is our major problem. In spite of Institute support and an increase of research projects, our students are badly undersupported. In several instances in recent years, we have been refused by promising candidates because more financial support was offered elsewhere or because they simply could not afford to come at all.

Master of Architecture Program

The M.Arch. Committee, chaired by Professor Imre Halasz, focused attention on the distinction between various design studio levels and standards for admission of students to higher level studios.

A program was begun this year of inviting well-known practitioners to teach intensive three-week projects for advanced students in the fall and spring terms. Fernando Domeyko, architect from Madrid, and Henk Reijenga, from Holland, taught in the fall term; Giancarlo De Carlo, director of the International Laboratory for Architecture and Urban Design in Urbino, and Charles Correa, architect from Bombay, taught in the spring.

Seven M.Arch. students travelled to Urbino in the fall term to study at the International Laboratory of Architecture and Urban Design (ILAUD). Christine Cousineau was instructor; Professor Halasz participated for three weeks, and Professor John Habraken was critic for one week of the term.

Plans were formulated this year for a consortium of schools to participate collectively in ILAUD. The University of Montreal, University of California at Berkeley, University of California at Los Angeles, and MIT will pool resources, faculty, and students at Urbino, beginning in 1981-82.

For the first time in several years, a "total studio," for students from M.Arch. and S.M.Arch.S. programs and the Department of Urban Studies, was offered in the spring term. The studio
School of Architecture and Planning

problem, requiring both planning and design solutions, was a large-scale design for Cambridge property adjoining the MIT campus. Professors John Myer and Gary Hack directed the studio.

Awards to graduating M.Arch. students in 1980-81 were as follows: the American Institute of Architects (AIA) Medal was given to James Batchelor, and Michael Raphael received the AIA Certificate. Paul Fallon won the Chamberlain Prize, and Jay Weber the Chandler Prize, both for achievement in architectural design. The Alpha Rho Chi Medal was awarded to Eric Schmidt.

Sharon Lee was one of the recipients of the Institute’s William L. Stewart, Jr., Award, which recognizes outstanding student contributions to extracurricular life.

S.M. Architecture Studies Program

The S.M.Arch.S. Committee, chaired by Professor Julian Beinart, continued to work on closer coordination of the groups within the program (Building Technology, Environmental Design, and Housing and Settlement Design).

Two core subjects were required of all S.M. Arch.S. students: Methods of Inquiry in Architecture Studies, taught by Professor Edward Robbins, and Special Problems in Architecture: Economic Analysis, taught this year by Professor Karen Polenske, of the Department of Urban Studies. A search is being conducted for a permanent faculty member in economics to join the program.

While all the faculty in the program engaged in research this year, more work needs to be done to integrate teaching and research investigations. There is a need to involve students in faculty research, which requires developing new formats to make research more fully a part of education.

Professor Harvey Bryan organized and offered new subjects in Heating, Ventilation and Air Conditioning (HVAC), with the cooperation of visiting practitioners Jagdish Prasad and Cam Bruce.

Professor Edward Allen chaired a biweekly faculty seminar of the Building Technology faculty and graduate students.

Richard Ness and Don Alberto, S.M.Arch.S. students in Building Technology, represented the Department at the AIA National Convention in Minneapolis. Four S.M.Arch.S. students were invited to participate in a competition sponsored by the Association of Collegiate Schools of Architecture (ACSA) in conjunction with the Solar Rising Conference. The attending teams made proposals for implementation of energy issues on a site in midtown Philadelphia. Altoff Mullah won an AIA Foundation fellowship.

S.M. Visual Studies

This degree program, comprised of the Film/Video, Creative Photography, Visible Language Workshop (VLW), Architecture Machine, and Center for Advanced Visual Studies, was chaired by Professor Nicholas Negroponte. The group struggled this year to find a stronger common basis for artistic and intellectual interaction in teaching. Long-term planning continues to be difficult due to the still uncertain future of the Arts and Media Technology program facility.

The VLW and Film/Video sections moved to new quarters in Building N52. The Architecture Machine renewed its facilities but continued to suffer severe space constraints.

A series of joint presentations was offered titled "Reflections in Art, Media, and Technology." Four two-day programs were offered during the year, comprised of workshops for S.M.Vis.S. students and public lectures. The series, coordinated by Paul Earls, Fellow at the Center for Advanced Visual Studies, featured Douglas Davis, Pierre Restany, Gordon Pask, and Jack Burnham, with a special presentation of work by Ken Knowlton.

Other highly successful public activities organized by the S.M.Vis.S. groups included the Monday Night Screening series at the Film/Video section. This forum for the S.M.Vis.S. program and the entire MIT community was supported in part by a grant from the MIT Council for the Arts. The screening series has secured a grant from the Louis B. Mayer Foundation. The exhibition series at the Creative Photography Gallery continued this year, including a show titled "New American
Nudes: Recent Trends and Attitudes." The exhibit coincided with the publication of a book, *New American Nudes*, containing the exhibition photographs and an introduction by Professor Arno Minkkinen, curator.

The S.M.Vis.S. groups continued to invite distinguished artists to teach short-term projects to graduate students. Lee Friedlander (who has held three Guggenheim fellowships for work in photography) was a visiting lecturer at the Creative Photography Laboratory. Visiting filmmakers who conducted workshops in the Film/Video section included Jean Rouch, a leading ethnographic filmmaker and Nam June Paik, a celebrated video artist. Nathan Lyons, director of the Visual Studies Workshop in Rochester, New York, gave an intensive workshop at the VLW on Words and Images.

*Positive*, the annual publication by graduate students in photography, continued into its second year, supported by a grant from the Polaroid Corporation.

Judith Black, graduate student in the Creative Photography Lab, received the Institute's Laya and Jerome B. Wiesner Award for Achievement in the Creative Arts. Her work, a forum and exhibition titled "Mother/Photographers," was supported in part by a grant from the MIT Council for the Arts.

**Ph.D. Program**

Professor Stanford Anderson was chairman of the Ph.D. program. Though the majority of doctoral candidates in the Department remain in the field of Architectural History, two students have been admitted to work with Professor Negroponte at the Architecture Machine. A slow expansion into other areas is foreseen, though a lack of funding for student fellowships remains a major hurdle. There is no lack of high-level demand for admission to the program, however, as applications continue from well-qualified candidates.

Events within the program included a series of six seminars directed by scholars of Islamic Architecture, and a lecture series by architects and architectural historians offered weekly during the year. Both series were organized and sponsored by the Aga Khan Program for Islamic Studies. The Ph.D. Forum, begun this year, offered the opportunity for History, Theory, and Criticism (HTC) students and related faculty to meet local scholars in seminars. Twelve scholars from the Boston academic community presented work at the Forum series in 1980-81. In addition, two symposia, "Religion, Law, and Architecture," and "Architecture and Politics," were presented. In each conference one of the invited speakers was drawn from the Department's Ph.D. students.

Awards to students in the doctoral program were as follows: Jay Chewning was made a Chester Dale Fellow at the National Gallery of Art, Washington, DC, and Martha Pollak held a fellowship at the Accademia dei Lincei, Rome. Mina Marafat and Moustafeh Abel Raouf were Aga Khan Fellows.

**BSAD Program**

This Department program, chaired by Professor Leon Groisser, worked at strengthening the sophomore program. Two subjects, Built Form Observation, taught by Professor Barry Zevin, and Issues in Architecture, taught by Professor Jan Wampler, represent a new format of introduction to architectural design. The subjects, which combine hands-on experience with solid theoretical foundation, are much in demand with MIT undergraduates. Sixty-three students enrolled in Issues in Architecture; more than 40 registered for Built Form Observation.

Our internship program continued into its third year, placing 16 students in architectural offices in the Boston area. Professors Allen and Rosemary Grimshaw were responsible for coordinating the program, which was offered during Independent Activities Period, 1981.
RESEARCH

Total funded research in the Department of Architecture has grown from $1,400,000 in 1979-80 to a total of $1,880,000 in 1980-81. Funding for research in the Architecture Machine Group nearly doubled during fiscal year 1981, and support for other Departmental research reached a total of $380,000.

Four projects constituted the major portion of research at the Architecture Machine: (treating the human interface with computers) Eyes at the Interface, Thinking in Color, Transmission of Presence, and Personalized Movies. A handful of smaller projects emerged with the more general interest in broadening Media Technology Research. These included: 3-D hardcopy, electrostatic printing of video, intermixing digital data with video on optical videodiscs, and instant and direct slide making from computer graphics.

Principal Research Associate Timothy Johnson received funding from the Department of Energy for the construction of an addition to the MIT Solar House V, open since 1977. The "Crystal Pavilion," designed by M.Arch. student Brian Hubbell, will demonstrate uses of heat mirror glass for passive solar energy in buildings. This research complements the continuing work, funded by Consolidated Edison of New York, on the development of ceiling panels for cooling, utilizing air conditioning at off-peak energy hours.

Professor Sandra Howell continued as principal investigator on "Determinants of Housing Choice," a project involving researchers in seven universities in the United States and Canada. Funding was provided by the Department of Health, Education and Welfare, Agency on Aging.

Professor Beinart obtained funding from the National Endowment for the Arts for a study of the forms of cities on the United States-Mexican border.

The National Endowment for the Arts also funded a project to be done by faculty in the Environmental Design group. The study, on the spatial impacts of new communication technologies, will be coordinated by Professor Robbins.

Professors Chester Sprague and Anne Vernez-Moudon worked this year on a project funded by the Lincoln Institute to study construction of infill housing in 16 representative US cities, and the potential impact of infill on overall supply and quality of housing.

Professor Bryan coordinated research on two funded projects. The first, research on daylighting, was sponsored by the US Department of Energy; the second, involving the use of physical scale modeling for energy analysis, was supported by the National Endowment for the Arts.

Professors Allen and Eric Dluhosch studied ways for improving finishing systems in housing in Egypt, as part of the MIT-Cairo University Technology Adaptation Program (TAP). Professor Habraken was principal investigator.

Research on Urban Tissue Design, supported by the Ernest A. Grunsfeld Memorial Fund, involved senior design students in a summer project under the leadership of Professor Habraken.

Professors Muriel Cooper and Ron MacNeil continued research for Compupaint, Inc., on the development of computer systems for the production of large-scale color imagery.

The Department also began this year to develop internal research projects upon faculty initiative. These projects are intended to be a vehicle for graduate education and to lay the foundation for possible outside funding in the future. In this context, Professor Sprague studied tractability of existing housing stock, Professor Dluhosch conducted a project on low-cost housing design in Brazil, and Professor Tunney Lee ran a research workshop on low-cost housing in Boston.

FACULTY

The Department invited a number of visitors for one term to teach architectural design studios in the M.Arch. program. In the fall, Professor Grimshaw taught a Level I studio, and Kyu Sung Woo
taught a Level II studio. In the spring term, Carmen Corneil, Associate Professor from the University of Toronto, Jack Patrick, formerly Assistant Professor at Howard University, John Wilson, Boston architect, and Mr. Domeyko directed Level II studios. Elizabeth Erickson, also a practitioner from Boston, taught at Level III.

Stuart Wrede visited the History, Theory, and Criticism group in the fall term to teach subjects on Scandinavian Architecture and Asplund and Aalto.

The Department was saddened by the death of a distinguished visitor, Bainbridge Bunting, noted scholar of the history of architecture. Professor Bunting had joined the Department for the spring term to teach subjects on American architecture and the architecture of H. H. Richardson. He was replaced by Douglass Shand Tucci and Cynthia Zaitzevsky.

Three Department faculty members received promotions this academic year. They were Associate Professor Leon Groisser, Executive Officer of the Department, to professor, and Assistant Professors David Friedman and Vernez-Moudon to Associate Professor.

Professors Wayne Andersen and Richard Tremaglio were on leave during the academic year, Professor Wampler in the spring term. Professor Shun Kanda took a leave of absence in spring to teach at the University of Tsukuba, Sakuera, Japan.

In September 1980, Professors Beinart and Hack presented papers at the Boston 350 Great Cities Conference, hosted by Harvard and MIT. Professor Howell gave a paper at the US-Japan Cooperative Science Conference in Tokyo.

Professor Cooper, director of the Department's Visible Language Workshop, was one of a number of distinguished citizens named "Grand Bostonian" as part of Boston's Jubilee 350 celebration.

Lawrence Anderson, dean emeritus, was a visiting professor of architecture at the College of Environmental Design, Berkeley, in the spring term.

Visiting Scholars

The Department continues to host each year a number of visiting scholars from universities around the world. This year they were: Professor Chong-Won Chu, Department of Architecture, Seoul University; Anders Eckholm, Lund, Sweden, visiting on a grant from the Swedish Council for Building Research; Zhao-Ye Guan, Department of Architecture, Tsinghua University, Beijing, China; Latife Gurer, Professor of Basic Design from the University of Istanbul, Turkey; Mrs. Bushayer Khairy, Cairo, Egypt; Professor Xiao-Wei Luo, head of the teaching group of the History of Architecture, Tong Ji University, Shanghai, China; Eung-Kyo Ryu, Professor in the Department of Architectural Engineering, Jeonbug National University, Korea; and Roya Yamamoto, Department of Architecture, Meiji University, Tokyo.

PUBLICATIONS


"Modern Architecture and Industry: Peter Behrens, the AEG, and Industrial Design," *Oppositions*, 21 (1980).


"Culture, Contact and City Form," *Spazio e Societa*, No. 13, 1981.


"Built Space, the Mystery Variable in Health and Aging," *Advances in Environmental Psychology*, Baum & Singer (eds.), Lawrence Erlbaum Assocs., 1981.


Schwimmer, Fotografie, (German photography magazine), June 1980.


N. JOHN HABRAKEN

Department of Urban Studies and Planning

The selection of a new Dean occupied most of our attention this year and raised some questions for us about the long-term directions which the Department and the School ought to pursue. By the end of the year, a new Dean, Professor Jean P. deMonchaux, had been appointed. His appointment was applauded by the Department. From the standpoint of our students and faculty, Professor deMonchaux's appointment signifies: 1) a continuing commitment to advocate the needs
of the poor and disadvantaged in the United States and in the developing world; 2) continued, and perhaps expanded, ties to the Department of Architecture; 3) an ongoing commitment to affirmative action and efforts to meet the special needs of minority professionals; and 4) a continued focus on professional education and efforts to build better theories of practice.

In addition to the search for a new Dean, financial aid issues dominated the year’s agenda. Federal cutbacks combined with rising tuition rates hurt in several ways. The number of applications did not increase, as we had expected. Minority recruitment efforts did not succeed, as in the past, in producing a large pool of qualified student applicants. Work-study programs in the public sector were cut back. Students, facing pressure to incur larger and larger debts for educational loans, lobbied hard for more financial help from MIT.

The volume of contract research in the Department was much talked about this year. We discussed the long-term implications (for faculty size, curriculum coverage, and student aid) of not being able to build our volume of contract research. Federal cutbacks in funding for applied social science research have made it almost impossible for us to increase our research volume very rapidly. We devoted a lot of attention to the undesirable side effects of pushing too hard to raise contract research just to cover ourselves financially. Research incentives of various kinds were considered in a series of meetings with our Visiting Committee and with the MIT administration. A new strategy, designed to encourage our faculty to devote more of their time to sponsored research, emerged.

This was also the year in which we initiated new contacts with the private sector. Following the advice of our Visiting Committee, we sought support for a new private sector intern program that will place our graduate students in internships with insurance, banking, and real estate companies in the Boston metropolitan area. Student interns will focus on new strategies for public-private partnership in the urban redevelopment process. We expect to begin the intern program in January 1982. Curriculum modifications may be needed to ensure the success of this program.

Given the attitude toward the public sector expressed by the Reagan Administration, we had to work twice as hard to place our students. Placement activities required a larger investment of time and resources. Most of our students found exciting jobs (many more in the private sector than in recent years), but the prospects for future graduates of the Department have dimmed.

All in all, we have the sense of hard times ahead for those with a commitment to urban revitalization, environmental protection, and efforts to seek social justice. MIT’s financial situation complicates matters further. Nevertheless, we are prepared to forge ahead and push even harder to achieve these goals and accomplish the special mission of the Department of Urban Studies and Planning (DUSP).

Undergraduate Program

Professor Joseph Ferreira assumed responsibility for managing our undergraduate program. He was assisted by Professor Lawrence Bacow. With the help of the Undergraduate Committee, they prepared and presented a proposal outlining a number of substantial changes in the S.B. program, which the faculty approved. The proposal must now make its way through various committees at the Institute. The proposal seeks to shift the S.B. program away from its current liberal arts and applied social science orientation toward more of a professional planning orientation. A change of name is, we hope, in the offing -- from S.B. in Urban Studies to S.B. in Planning and Public Affairs. We will seek more double majors and concentrators. We intend to build a new core of undergraduate planning subjects emphasizing skill building in public policy analysis, community intervention, and public management. We will continue to provide course work for undergraduates interested in law and public policy as well as those interested in environmental planning. Our joint public policy degree with the Department of Political Science will also remain intact.

Over the past few years, the number of Course XI majors has dropped sharply (from a high of 60 to the current low of 15). We are convinced that this is a function of the changing interests of undergraduates entering MIT. Until the general orientation of the student body changes (as we expect it will), we have decided to focus our undergraduate teaching efforts on the needs of: 1) double majors interested in a supplementary major in planning and public affairs; and 2) concentrators interested in our humanities sequences in urban studies and environmental planning.
Professional Degree Program

Professor Langley Keyes and the members of the Master in City Planning (M.C.P.) Committee spent a substantial amount of time this year reconsidering the core curriculum. Throughout the spring semester, a subcommittee under the direction of Professor Don Schon reexamined the four basic core courses in the professional degree program and discussed alternative approaches to teaching the material and skills they cover. The subcommittee issued a preliminary report calling for more of an emphasis on the case method of teaching, as well as a redesign of the core as a single integrated experience rather than as a set of separate courses. Their recommendations were presented to a Summer Study Committee that will report back to the M.C.P. Committee next fall.

A number of faculty members involved in the MCP program spent a considerable amount of time developing a proposal seeking funds for a multi-year study of planning practice. This study would be aimed at grounding current teaching in a clearer sense of the nature of recent professional practice. The proposal will be developed further; foundation support will be sought.

In the past year, we strengthened our link to the MIT Writing Program. Louise Dunlop was appointed jointly by the DUSP and the Writing Program to implement a special diagnostic and tutorial assistance program for our students. This collaboration has been quite effective and will be continued next year.

The M.C.P. curriculum is still in flux. Methods modules, core courses, streams of course work in eight separate areas of specialization, and field-linked activities are all part of the mix, but the exact recipe is still a point of contention. Also this year, the faculty approved a one-year experiment with a new thesis option -- students will be allowed to substitute a less extensive thesis (representing fewer hours of course time) and additional classroom hours for the usual 30-unit thesis. This option will go into effect next year and will be reviewed in June 1982.

Ph.D. Program

The Ph.D. Committee, under the leadership of Professor Robert Fogelson, took pride in the fact that we graduated our largest number of Ph.D.s ever (16) this year. The Committee’s past efforts to improve the monitoring of student performance have obviously paid off. This year, the Ph.D. Committee examined several other aspects of our doctoral program. They amended the existing methods requirement, substituting a stiffer statistics requirement. They continued to refine the definition of major and minor fields that our students can designate as exam areas. There was also a belated effort to consider additional shared “core” experiences for doctoral students (beyond the required first-year seminar), but that found little, if any, support.

Once again our instructors program proved successful. Fifteen advanced doctoral students assumed limited teaching responsibilities under the tutelage of the DUSP faculty. We will continue to emphasize the importance of a teaching apprenticeship for each of our doctoral students.

Teaching posts continue to be available to our graduates. At least 40 assistant professorships in urban studies, planning, and public policy were identified across the United States this year. All five of our June graduates seeking teaching positions were successful in finding attractive academic positions.

SPURS

The SPURS program, under the direction of Professor Lloyd Rodwin, had another very active year. There were 14 fellows this year, four from the Philippines, three from Korea, two each from Egypt and Mexico, and one each from Japan, Colombia, and Israel. Twelve of the fellows came from the public sector, and seven were either heads of their sections or assistant directors. SPURS also hosted several guests, including Professor Giovan Francesco Lanzara, from the University of Bari, Italy. The SPURS faculty was more active than ever. More organized interactions with international development agencies in the United States were organized for the fellows.

Careful consideration is currently being given to short-term training institutes, SPURS spinoffs that would be held in other countries, managed by the SPURS faculty.
The SPURS luncheon series continued to attract top-flight speakers from all over the world. The Thursday evening seminar series provided the fellows with an opportunity to evaluate each other's work. SPURS accepted four Humphrey Fellows this year. Alan Strout represented SPURS at the Humphrey Program Coordinating Seminar in New York.

The SPURS program concluded a formal agreement with CONACYT, the Science Advisory Agency of Mexico. We will accept at least three SPURS candidates a year from Mexico as long as they can meet our admissions requirements. For the 1981-82 academic year, six applicants were considered and two were accepted.

Community Fellows Program

National interest in the Community Fellows Program continues to grow. Applications increased again this year. An independent evaluation of the fellows program was completed this year. The evaluation was undertaken by a National Review Committee, under the direction of Greg Smith (MIT Corporation) and Dr. Mario Fantini, Dean of the School of Education at the University of Massachusetts. After an extensive examination of all aspects of the fellows program, the review committee recommended that the program be continued with full MIT support. Several suggestions were made regarding possible improvements, including the need to tighten the connection between the activities of the fellows program and the Department's teaching and research in community economic development. The need to strengthen the mentor system was also noted.

Under the direction of Dr. Melvin King, the Community Fellows Program continues to flourish. The MIT administration, after reviewing the report of the National Review Committee, agreed to ensure two more years of full financial support and to assist Dr. King and others in long-term funding efforts.

OTHER ACCOMPLISHMENTS AND PROBLEMS

The Department received a total of 326 applications from prospective applicants seeking admission to our graduate programs. Of the 326, 250 were for the M.C.P. program and 76 were for the Ph.D. program. A total of 52 applicants were offered admission to the Master's program, with a waiting list of 20. Twenty-five applicants were offered admission to the Ph.D. program with a waiting list of eight. Nineteen students will be entering the Ph.D. program next year (including two students who were readmitted). Forty will be entering the M.C.P. program, including three joint degree candidates with the Department of Architecture. These acceptance and admission ratios are the best among the nation's planning schools and among the very best at MIT.

The Department has initiated a five-year relationship with the Lincoln Institute for Land Policy (in Cambridge, MA). The DUSP and the Lincoln Institute will sponsor an annual seminar on planning and development in the US and Europe. This year, Professor Lawrence Susskind and Pierre Laconte (Louvain-la-Neuve, Belgium) offered a joint seminar at the Lincoln Institute, focusing on comparative new town planning. The seminar drew an excellent mix of mid-career practitioners and graduate students from throughout the Boston area. Every spring, through 1986, similar joint seminars will be offered.

The Department has been active in the work of the National Accreditation Task Force of the Association of Collegiate Schools of Planning (ACSP). ACSP, in conjunction with the American Planning Association (APA), is moving toward a formal system of graduate school accreditation. The US Council on Professional Accreditation (COPA) has given preliminary approval to the joint APA-ACSP accreditation proposal. The standards and procedures that will be used for accreditation are currently being drafted. The seven-person National Accreditation Task Force includes DUSP department head, Lawrence Susskind.

The DUSP Postdoctoral Fellows Program attracted excellent applicants again this year. Modeled after the Moore Instructorship Program in Mathematics, postdoctoral appointments in the DUSP allow recent Ph.D.s to spend a year studying, writing, and teaching at MIT. Two excellent postdoctoral candidates have been selected for next year.
Our new research project ought to be noted: the Impact 21 project. A multi-university consortium, based in the Department of Urban Studies and Planning, has initiated a three-year analysis of the impacts of Massachusetts' new tax limitation measure. Faculty from five departments at MIT, as well as colleagues from 11 other universities, are involved. Funds from the President's Office at MIT and from Harvard University helped to kick off the project.

Personnel Changes

There was one promotion this year. Karen Polenske was promoted from associate to full professor. There were no tenure cases for review. There was one departure from the faculty: Professor Arthur Solomon accepted a position with the Sears Corporation in Chicago.

Several temporary appointments were made this year to fill vacancies while searches for replacement faculty got under way. Professor Raj Sah joined the faculty to teach economic development theory and project analysis in developing countries.

One additional appointment deserves special note. Robert Landmann, former assistant administrator of the Community Services Administration (under President Carter) will join our staff as a research scientist. Mr. Landmann will be involved, full time, writing proposals and seeking sponsored support for our research in the field of neighborhood and community economic development. Mr. Landmann will involve all of our faculty and students with shared interests in this field. It is our belief that this is the best way for us to expand the volume of our sponsored research.

Problems

The Department is still struggling with two persistent problems: insufficient student aid and lack of space for research activities and faculty offices. The student aid problem has reached the point where we can no longer compete for some of the students we are most anxious to attract to our graduate program, particularly minority students. While our student acceptance ratio is very high, we are still losing some of the students we would most like to have. Internship programs have been cut by the Reagan Administration. We have very limited income from School-wide and departmental endowments. Tuition increases continue to make it impossible for us to guarantee our graduate students even half the funds they need to cover tuition and living costs at MIT.

The Institute administration bailed us out this year, with a special "once-only" allocation of additional funds. The problem, however, is sure to get worse. Some new approach to financing our graduate students must be found, especially given the low salary expectations of public sector professionals, and therefore, the uneasiness they feel about borrowing extensively.

Every year the Department complains about the lack of space and the debilitating configuration of the spaces we presently occupy. We have decided to try to make the best of the decentralized pattern we now inhabit. This will not, however, solve the space shortage. We are still hoping to acquire at least one floor of Building 11 when the Medical Department moves to its new offices on the East Campus. This would provide much-needed space for faculty and doctoral students now crowded into inadequate space.

It was, once again, an extremely exciting year. The Department continues to reflect all the tensions and possibilities of the community at large. This is as it should be for a practice-oriented program with half its activities based in the community and half in the academy.

One final note: All DUSP students, faculty, and alumni regret Professor William Porter's decision to step down as Dean of our School. He has provided inspiration and patient leadership during the past 10 years of rapid expansion and intellectual ferment. His guidance will be missed. His many contributions are greatly appreciated.

LAWRENCE SUSSKIND
Laboratory of Architecture and Planning

The year 1980 was one of continued growth for the Laboratory of Architecture and Planning (LAP). The majority of the School's researchers now base their research activity in the LAP. While the LAP continues to support initiatives of individual faculty members, we are taking increasing initiative to bring together faculty to define and pursue research topics.

The research and special programs conducted through the LAP continue to serve its three broad objectives of furthering the state-of-the-art of practice and teaching in the fields of architecture and planning; linking the School with the activities of practice; and encouraging research about areas of emerging concern to society and the profession.

LAP staff and faculty continue their sustained interest about such topical areas as: environmental management, energy and buildings, neighborhoods, research and teaching methodology, regional analysis, adaptive housing, environmental designs, citizen participation and planning, the relationship between culture and built form, use of the media by public agencies, and new settlement patterns.

RESEARCH

The Passive Design Curriculum Development project developed architectural curriculum materials in the area of building climatology. Professor Edward Allen was the principal investigator, and the work was funded by the Department of Energy.

The Impact of Telecommunications Technology on Settlement Patterns project began exploratory efforts to define a longer-term research agenda. Professor Julian Beinart is the principal investigator. The work is funded by the National Endowment for the Arts.

The Relating Transportation to Neighborhood Change project assessed the effects of changes in transportation technology and energy costs on neighborhoods. Dr. David L. Birch was the principal investigator, and the work was funded by the Department of Transportation.

The Economic Role of Small Businesses study analyzed the role that small businesses play in creating jobs and bringing about economic change. Dr. Birch was the principal investigator, and the work was funded by the Small Business Administration.

The Community Energy Impact study continues to analyze the impact of changing energy supply and cost on the development of neighborhoods. Dr. Birch is the principal investigator, and the work is funded by the Department of Energy.

The National Employment Shifts project completed a study of how aggregate employment changes in different parts of the country are caused by the behavior of individual firms. Dr. Birch was the principal investigator, and the work was funded by the Department of Commerce.

The project on General Model for Analysis of Small Business Development developed generalized models for small-scale analysis. Dr. Birch was the principal investigator; and the work was funded by the Dun and Bradstreet Corporation.

In addition, Dr. Birch continued further work with the Community Analysis Model (CAM). A project extending CAM to accept transportation changes is funded by the Department of Transportation. Projects evaluating alternate growth strategies are funded by the State of North Carolina.

The Energy-Conscious Design project utilizes visual documentation techniques and physical scale models for energy-conscious design education. The principal investigator is Professor Harvey Bryan, and the work is funded by the National Endowment for the Arts.
The Daylighting Project deals with analytical and physical scale modeling of interior daylight illumination. Professor Bryan serves as the principal investigator, and the work is funded by the Lawrence Berkeley Laboratory.

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

The Determinants of Housing Choice Among Elderly project analyzes the strategic personal and institutional issues which affect the decisions of aging people to move or stay in their residences. Professor Sandra Howell is the principal investigator, and the work is funded by the Administration on Aging.

The Boston Neighborhood Network (BNN) is an innovative project which attempts to make university-based research useful to the leadership of neighborhood organizations. The Network presents workshops, seminars, and conferences about diverse subjects, such as mortgage lending patterns, use of appropriate technology, and social indicators as a tool for guiding neighborhood development. Visiting Professor Robert Hollister is the principal investigator, and the work is funded by the National Science Foundation. In January 1981, after two years with the Network administratively based in the LAP as an MIT program, the BNN was established as a nonprofit community organization. MIT continues to participate as a contributor. Professor Tunney Lee now serves as the principal investigator.

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

The Off-Peak Air Conditioning project continues research and development of a full-scale, experimental off-peak cooling system. Mr. Johnson serves as principal investigator and the project collaborates with the Department of Mechanical Engineering. The sponsor is the Consolidated Edison Company.

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

The Computational Design and Demonstration Project was an investigation of how tabular data could be presented and identified for use by community planners. The study was carried out for the Commonwealth of Massachusetts under subcontract for a private sector planning consulting firm. Dr. Klensin served as the principal investigator.

The Energy Use in Buildings project analyzed energy performance in an existing commercial office building. Professor Douglas Mahone served as the principal investigator, and the work was funded by the Beacon Companies.

The Citizen Involvement in the Budget Process project provided analytical, technical, and organizational support to citizen task forces working to determine how government funds can be allocated to social service needs. Citizen task forces are assisted in mediation efforts with town selectmen. Professor Lawrence Susskind was the principal investigator, and the work was funded by the Town of Arlington, Massachusetts.

The Impact: 2½ program is carried out by an inter-university consortium, directed by Professor Susskind. The program aims to monitor the long-term impact of the state-wide program of tax and spending reduction authorized by Referendum Proposition 2½, passed in November 1980. The program is funded by a number of foundations. The LAP serves as the center of operations for nine participating research organizations.

The ongoing Environmental Impact Assessment project continues investigation of the ways in which public agencies can better project and assess environmental impacts of proposed policies, programs, and public investments. Professor Susskind is the principal investigator.
The Environmental Mediation project explored techniques for mediating environmental disputes. Professor Susskind was the principal investigator, and the project was funded by the Environmental Protection Agency.

The LAP serves as the overall administration home for the Aga Khan Program in Islamic Architecture. In addition to professorships and fellowships located in the Department of Architecture and a documentation project centered in the Rotch Library, there are summer institutes abroad, a faculty exchange program, publications, and other activities to strengthen the program and link it with its counterpart program at Harvard, with other programs here at MIT, and with other institutions and individuals throughout the world. Dean William L. Porter is the Program's director. The Program Office was consolidated at MIT in the spring.

Assumptions Underlying Planning Thought is a program which looks at the assumptions and theory underpinning planning practice in various cultures. A series of workshops and seminars in the US and abroad bring together academicians and practitioners to consider the issues and their implication for professional education. The program, funded by the Lincoln Institute, is coordinated by the LAP. Dean Porter is the principal investigator.

The Architectural Case Studies program is now preparing two prototype series of cases. One focuses on issues concerning energy-conscious design. Several of these cases have been tested at continuing education programs of the American Institute of Architects and the Association of Collegiate Schools of Architecture. LAP Director Michael Joroff and Mr. Mahone are the principal investigators, and the work is funded by the National Endowment for the Arts. The other series of cases focuses on environmental design for special needs populations. Several of these cases have been tested in classrooms in three universities. This series is funded by several sources, including the Massachusetts Department of Mental Health. LAP Director Joroff is the principal investigator.

The Design Collaborative for Supportive Environments is a program which provides research-consultation services to institutions and organizations which seek to adapt physical environments to meet the needs of populations with special needs. LAP Director Joroff is the principal investigator, Beatrice Lewis is the project director. The work is funded by various sources, including the Massachusetts Department of Mental Health.

SPECIAL PROGRAMS

The LAP continues to use its Continuing Education Program both as a means of providing a service to alumni and practitioners, and to promote the School's research agenda. Faculty and local professionals teach the courses. The courses offered during the summer of 1980 were: Passive Solar Energy -- Tools for Design Application (D. Mahone); Planning for Neighborhood Change (R. Hollister and D. Auger); Environmental Design and Planning: An MIT Symposium (M. Elliot, coordinator); the Planning Process (T. Nutt-Powell); the Realities of Historic Preservation (R. Nelley); Design in Islamic Countries (W. Porter); and Improving Professional Practice (W. Ronco). We have begun planning for a program which will extend our continuing education program to in-house programs for large architectural firms.

In August 1980, for the second year, the LAP hosted the Energy Design Institute of the Association of Collegiate Schools of Architecture, an intensive week-long course for architectural faculty from schools throughout the country. MIT faculty from the Schools of Engineering and Architecture played a leading role. The LAP managed two major special programs in the fall of 1980. One was the MIT day in the "Great Cities of the World Conference," the event which climaxed the "Boston 350 Celebration." Major presentations about how city form and plans evolve to reflect their cultural context were made by Professors Beinart, Hack, and Porter. Panel participants in the MIT day were the mayors of Nairobi, Hong Kong, Dublin, Hangchou, Rome, and Montreal. The LAP, with support from MIT's Office of the President, hosted a luncheon and reception for 300 international visitors. The LAP, in collaboration with faculty of the Department of Architecture, presented a three-day international symposium entitled, "Housing and Human Settlements: Looking Ahead into the Eighties." The focus of this meeting was the exploration of new approaches to the many problems facing nations of Latin America and the US in planning, finance management, and technology utilization in the fields of housing and human settlements. Fifty invited participants represented Brazil, Mexico, Venezuela, and Argentina.
The LAP also hosted several one-day symposia. "International Issues in Environmental Design," chaired by Dean Porter, brought together academicians and practitioners from the United States, France, Turkey, Israel, and Egypt. "Energy: Agenda for Building Research," brought together the President of the American Institute of Architects, faculty from the Department of Architecture, the Energy Laboratory, and the Department of Mechanical Engineering to explore issues of mutual concern for research and practice. The symposium, "Assumptions Underlying Major Schools of Planning Thought," brought together academicians and practitioners from the United States and France to begin a series of meetings to be carried out over the next few years. Each year's exploration will focus on planning in different cultures. We have found that one- or two-day symposia which bring together academicians and practitioners are an excellent way to frame and launch longer-term research efforts.

**DISSEMINATION OF RESEARCH FINDINGS**

The LAP remains committed to disseminate the findings of research to as wide a professional and public audience as possible. The Publications Program, which offers almost 50 titles, had major promotional displays at the annual meetings of the Association of Collegiate Schools of Architecture and the American Planning Association. The Environmental Impact Assessment Review, published by Plenum Press, is edited by LAP staff under the direction of Professor Susskind, the Review's senior editor. The Review, now in its second year of publication, has been supported by the private sector. Dean Porter, with associates from MIT and the University of California at Berkeley, has begun development work on a new journal about environmental design. Funded by the National Endowment for the Arts, the project is administered by the LAP.

Included on the LAP staff are professionals with considerable experience using the electronic and print media. They work with LAP researchers to shape effective dissemination strategies to reach a broad public as well as professional audience.

**STAFF**

The LAP core research and administration staff continues to be strengthened. Donna M. T. Herlehy, the LAP's administrative officer, became the LAP's assistant director in the latter part of the year. Laurie Panzini joined the LAP's core support staff.

Several new research staff were appointed to the LAP this year: Research Associate Laura Sullivan serves as assistant director of the Boston Neighborhood Network; Mona Serageldin, coordinator of special programs, Aga Khan Program, was appointed as a principal research associate; Douglas Mahone, formerly Assistant Professor of Architecture, became a research associate of the LAP. Sally Friedman and Amy Erlich joined the LAP's staff as technical assistants, to work on the study of elderly housing; Bernard Spring, president of the Boston Architectural Center, is a new research affiliate; Donna McDaniel also became a new research affiliate; Margaret Sevcenko, coordinator of publications for the Aga Khan Program at MIT and Harvard, moved to MIT with the consolidation of the Program offices here. Professor Mikihiro Mimura from Tsukuba University in Japan, was a visiting scholar. LAP Research Associate Donna Duerk worked with the US Department of Education under the intergovernmental Personnel Act. Continuing on the LAP staff were the following: Senior Research Scientist David Birch; Principal Research Scientist John Klensin; and Research Associates Deilia Gallinaro, Rebecca Packard, and William Parsons. Mr. Parsons was designated director of Systems Development for the Program on Neighborhood and Regional Change. Dr. William Ronco continued to direct the LAP's Continuing Education Program. Thomas Piper and Robert Whittlesey and Dr. Nancy Hetzel continued as research affiliates of the LAP. Mary Curran joined the research support staff of the LAP.

In addition to LAP-based research work, several members of the LAP staff were busy with professional activities. LAP Director Joroff was elected chairman of the Board and president of the Architectural Research Centers Consortium (ARCC); in this capacity he will be chairing a workshop to develop a research agenda for the soon-to-be-launched building sciences program of the National Science Foundation. For ARCC he is also directing a study of the architectural research industry.
School of Architecture and Planning

in the United States. Dr. Birch was awarded the Small Business Administration researcher of the year award for his study, the Job Generation Process. Dr. Klensin continues to participate as a member of the American National Standards Institute technical committee for PL/I standardization, and published articles in the American Statistician, and proceedings of the American Statistical Association, and COMPSTAT 80.

Beatrice Lewis chaired the Environmental Design Committee of the Association for the Care of Children's Health, and Rebecca Packard was a member of the project team which designed a prototype course about world conservation for the International Union of Conservation and Naturalists. Ms. Herlehy served as the director of training for the Boston architectural tour group, Boston-by-Foot. Research Affiliate Thomas Piper was awarded the ACE (the equivalent of an Emmy) for a public affairs documentary produced for cable television.

COLLABORATIVE ARRANGEMENTS

The LAP continues to extend its breadth of involvement in projects through collaboration with a variety of organizations. The School of Architecture and Planning and the School of Engineering have agreed upon plans to launch a new MIT research center, the Center for Energy-Efficient Buildings and Systems, as a joint venture. The successful inception of this program is due in large measure to the close collaboration between the principals in the two Schools and the Energy Laboratory. The program of the proposed center will be integrated around an innovative concept, the use of physical scale models of buildings and components. The LAP will serve as the coordinator for the School as well as the administrative area for the center. The plan is now awaiting formal approval by the MIT administration.

LAP projects currently involve formal collaborative arrangements with researchers in more than two dozen universities. The LAP is a leader of the Architectural Research Centers Consortium (ARCC) which represents and promotes collaboration among the 20 major university-based research centers. The LAP is one of a dozen university participants in the Impact 2½ project as described above. The LAP is also one of four universities playing a major role in the Boston Neighborhood Network, a nonprofit community service-cum-research organization, which was originally created, planned, and operated through the LAP. The LAP continues to collaborate with the Harvard Graduate School of Design's Office of Special Programs with whom we offer our Continuing Education Program. This year, the LAP began participating in the continuing education program of the American Institute of Architects.

The LAP is an active participant in the Institute's efforts to launch collaborative research and education programs with the University of Tokyo. This year the LAP reached initial agreements about strategies for collaboration with counterparts in the departments of architecture and planning. The LAP is also coordinating the School's collaborative energy research with the Technical University of Berlin. We will host a delegation of architecture faculty and students in the fall of 1981.

This year the LAP became an associate member of the Rome-based ICCROM, the international organization concerned with preservation of historic artifacts and places. This move formalized working relationships between ICCROM and several faculty of the Architecture Department.

DEVELOPMENT PLANS AND ISSUES

The LAP will increase its efforts to coordinate development strategies within the School and will primarily provide support to projects which support its development agenda set with advice from the School council and senior faculty. The LAP will continue to seek advice and support from practitioners in the field, members of the School's Visiting Committee, and representatives of client organizations.

Although we are confident of the LAP's continued growth and vitality, the coming year will pose some difficult problems. The extensive cutback of Federal funding for social science and policy
research will seriously hinder our fundraising efforts, as will the increased competition for foundation funds generated by cutbacks of Federal support for all types of research. The restrictions imposed by the Office of Management and Budget's A-21 are also having a severe impact on our work because of the restriction concerning overhead waiver for our broad array of community service-oriented research.

MICHAEL L. JOROFF
School of Engineering

The 1980-81 academic year was one of growth, reflection, and change within the School of Engineering. The strong interest in engineering education continues to challenge the time and ingenuity of the School's faculty. The undergraduate enrollment has stayed at a high percentage, close to 70 percent of all the undergraduates registered in a School. The growth has leveled out in the last year or two, but the School remains popular among undergraduates. At the graduate level, enrollments have continued to increase, up approximately 10 percent over the 1979-80 academic year. There are now about 4,600 undergraduate and graduate students in the School of Engineering out of a total MIT enrollment of approximately 8,400 which includes about 1,000 freshmen who are not affiliated with any School. The foreign student percentage of the graduate population has stayed reasonably constant.

Faculty recruiting remains a major issue of concern as it has been for several years. The need for Ph.D engineers in our society has grown at a record pace, while the rate of graduation of Ph.D candidates has decreased. In recent years, there have been roughly 2,600 Ph.D.s in engineering graduating annually in the United States and, of these, approximately 1,100 are foreign nationals. The nearly 300 schools in the United States offering undergraduate degrees in engineering have more than 2,000 unfilled faculty positions. Since the industrial demand for doctoral students has increased, the competition for new faculty remains extra-ordinarily competitive.

The academic activities of the past year have led to the creation of a new master's degree program in the Management of Technology. This program, which is joint between the Sloan School of Management and the School of Engineering, has been created to fill the needs for management education of practicing engineers working in areas of high technology and high growth industries. The program was approved by the faculty and the Corporation, and the first class of students was admitted in June for a full-year program. Professor Edward B. Roberts, David Sarnoff Professor of Management, is the Director of the program and Professor J. Herbert Hollomon of the Center for Policy Alternatives is the Deputy Director. The program is under the administrative direction of Jane Morse.

The Engineering Internship Program has continued to prosper under the direction of John Martuccelli. The program is designed for students who will spend three summers in industry after their sophomore, junior, and senior years; as well as the fall semester of their fifth year of school. At the end of the program they will receive both a bachelor's and master's degree. At present, there are more than 30 companies participating in the program and approximately 70 students enter the program each year.

A special School of Engineering Task Force on Energy, chaired by Professor Gerald L. Wilson, completed its study during the past year. The result of the study indicated that there are important opportunities for the School of Engineering in energy education and research. The report recommended the creation of standing committees to assist in the planning and review of energy education and research, and two committees have been appointed for this purpose. In the forthcoming years we expect the initiation of new academic programs, with multiple choices for engineering students to learn about energy issues and potentials and possibilities. There are plans as well for the Institute and the School of Engineering to play a major role in energy development.

There were a number of important changes in personnel within the School of Engineering during the past year. Professor Joseph Sussman was appointed Head of the Department of Civil Engineering effective on September 1, 1980, to replace Professor Frank Perkins, who became Associate Provost.
Professor Norman Rasmussen, Head of the Department of Nuclear Engineering, asked to be relieved of that responsibility at the end of the academic year. Professor Neil E. Todreas has been appointed as the new Head of the Department of Nuclear Engineering effective July 1, 1981.

Professor Jack Kerrebrock of the Department of Aeronautics and Astronautics has asked for leave of absence to become Associate Administrator for Aeronautics and Space Technology in the National Aeronautics and Space Administration (NASA) beginning July 1, 1981. Professor James Mar was appointed Head of the Department of Aeronautics and Astronautics and will serve in Professor Kerrebrock's place until his return.

I have asked to return full-time to the Henry R. Luce Professorship of Environment and Public Policy at the end of the 1980-81 academic year. A search committee was appointed by the Office of the Provost, and Professor Gerald L. Wilson, Head of the Department of Electrical Engineering and Computer Science, was selected as the new Dean of the School of Engineering. Professor Wilson will assume the responsibility of the office on September 1, 1981. Professor Kent F. Hansen, who has served with me as the Associate Dean, will return to full-time faculty status on the same date.

Professor Joel Moses will become the new Head of the Department of Electrical Engineering and Computer Science, and Professors Richard Adler and Peter Elias will be the Associate Department Heads; all effective September 1, 1981.

ROBERT C. SEAMANS, JR.

Department of Aeronautics and Astronautics

Enrollment in the Department increased again this year, following the trend of the past several years. The introductory subject, Unified Engineering, was taken by 81 students. Most were sophomores, but a few juniors were also introduced to Course XVI through this subject as well. There is an indication that undergraduate enrollment has not yet peaked because some 90 sophomores are expected in the fall term of 1981.

Graduate enrollment has been relatively stable at 150, with about 50 percent S.M. candidates and 50 percent Ph.D. candidates. Indications are that the large undergraduate classes of recent years will be reflected in increased graduate enrollment beginning with the fall semester of 1981, when 170 students are expected to enter. Of this enrollment, 71 students will be new.

There is a clear trend of decreasing student enrollment in Ph.D. programs. In 1978, 49 percent of the graduate enrollment were Ph.D. candidates. In 1981, the percentage dropped to 29 percent. This seems to be the result of very attractive employment opportunities in aerospace engineering. While a year or two of graduate work toward an S.M. degree is judged to be cost effective, the additional two to four years required by Ph.D. programs is not. Many students choose to forego the Ph.D. for the high salaries in industry.

This trend at the graduate level, combined with the larger undergraduate classes, has forced a shift in emphasis from research toward classroom instruction. While the Department remains committed to the maintenance of its tradition of personal attention to both undergraduates and graduates alike, continued restricted growth in the academic budget is making this increasingly difficult to do.

Fortunately, the Department has been able to add several assistant professors to the staff over the last two years. Five are supported by endowments; two Charles Stark Draper Career Development Assistant Professors; two Boeing Assistant Professors; and one assistant professor in the area of ceramic applications to gas turbines, funded by the Detroit Diesel Allison Division of General Motors. An additional assistant professor will be added in the field of experimental fluid mechanics in the fall of 1981. There are needs in the areas of man-vehicle engineering and flight transporation which can only be met by the addition of junior faculty members.
Budgets for maintenance and acquisition are clearly inadequate to meet the needs of a rising enrollment. The most difficult problems to solve are those which have arisen from trying to keep abreast of demands for more space, facilities, and equipment. Both space and equipment available for the very important Undergraduate Projects Laboratory are inadequate. Renovation of the Building 33 basement, planned for summer 1981, will ease the space problem, but the problem of inadequate equipment will continue to grow.

A subject of much discussion within the Department during the last year was the inadequate accessibility students had to computing facilities. A Departmental Computer Committee was formed to address the overall situation of computational facilities and to establish policy within the Department. A set of accommodations for meeting these complex requirements was developed.

The issue of student access to computers for academic (non-research) usage was highlighted at the Department's Visiting Committee meeting in March by a group of very vocal students. Briefly, the students perceive interactive use of a computer as an integral part of their thought process, and not as an optional activity. They feel that unlimited access to computation should be a part of their MIT engineering education. The faculty encourages this attitude, having decided two years ago to incorporate the use of computation in subjects wherever it was appropriate. Discrete mathematical approaches implemented numerically are the main thread of modern solid and fluid mechanics, and the computer plays an essential role in systems engineering as well. Computer graphics are rapidly replacing manual drafting and illustration in the aerospace industry, and these trends are recognized by students. Now the Department finds it difficult to meet even the most immediate requirements for computers and computer time within the general budget. External funding is being sought to meet these immediate needs. It is apparent that this is a long-term problem, not only for Course XVI, but for the Institute.

An important trend is the increasing emphasis on Astronautical Engineering, both in research and in instruction. It has been true for some time that more than half of the undergraduate students are interested in space rather than in aeronautics. But until recently neither the research programs of the Department nor its array of subject offerings catered to this overwhelming interest. With the growing importance of the satellite industry and the renewed activity in space attendant on the operational status of the Space Shuttle, it is clear that a good fraction of the most exciting and challenging jobs in aerospace will soon be in astronautics. Consequently, the Department is placing more emphasis on research and instruction in the disciplines critical to the engineering exploitation of space.

Undergraduate Program

The Undergraduate Office, under the direction of Professor Emmett A. Witmer, has undertaken the correlation of advanced undergraduate subjects within the content of Unified Engineering. A complete set of detailed syllabi of these subjects is available at several locations within the Department and are used by students and faculty. This computation process has already led to useful communication and, we hope, more will follow.

Two new subjects were created in response to the need for more coverage of astronautical disciplines. They are 16.03 Aerospace Heat and Mass Transfer, and 16.06 Space Gas Dynamics. The undergraduate subject, 16.023 Introduction to Computational Fluid Dynamics, has been designed to offer undergraduates entry into this rapidly growing activity.

The Department is committed to offering an Undergraduate Microprocessor Laboratory, with the purpose of instructing undergraduates in the use of microprocessors for control of mechanical systems. This is being done because subjects offered in Course VI are oversubscribed. In addition, so many prerequisites are required that it is difficult for our students to make room in their schedule for the additional subjects. Associate Professor William Widnall, Assistant Professor John Thomas, and Stanley Sasaki, a graduate research student, have completed the design of the Laboratory, which will be offered in the fall of 1981 to a class of about 10 students. Some of our measuring equipment in this new laboratory is antiquated and it is our hope to replace these items with current technology.
Graduate Program

As noted previously, the graduate student population has been relatively stable, but it is expected to increase in 1981 from 150 to 170. At the same time, available funding for endowed fellowships continues to diminish as endowment income decreases, and the cost of fellowships increases. Thus, the increasing number of graduate students must be supported by research assistantships at a time when research support is also becoming tight. So far, this has not been a major problem, but an ever-increasing level of faculty effort is required to ensure the availability of funds.

The Department is competing well for the available pool of graduate students. Of the 96 applicants who received offers, 71 have accepted for the fall of 1981. Half of the 16 women and/or minority candidates who were offered admittance have accepted.


A cooperative agreement has been negotiated with the Charles Stark Draper Laboratory to develop a graduate curriculum in Fault Tolerant Systems Engineering. Professor Wallace E. Vander Velde will work with the Draper staff to transfer the methodology developed at the Laboratory into a Departmental subject offering. This effort will be supported by the Hertz Foundation.

This year Professor Laurence R. Young and Assistant Professor Robert V. Kenyon collaborated with Dr. Mark Connelly in teaching 16.36 Flight Simulation. The use of simulators for research and training is of growing importance in aeronautics and space, and the Department sees its role in this area growing in the future.

The subject Structural Design of Gas Turbines was offered for the first time in academic year 1980-81. MIT is the only school in the United States to offer instruction in this very important technology. Academic programs in gas turbines historically have been centered around fluid mechanics.

Flight Transportation is unusual among the Department's activities because of the number of self-supporting graduate students it attracts. Many are foreign nationals sent to MIT to study the modern techniques of airline management. This is a subject in which the faculty and staff of the Flight Transportation Laboratory have a unique expertise. These students come for S.M. degrees. They require thesis supervision, often on topics of their own selection which are outside the research scope of the Laboratory. Consequently, faculty effort in thesis supervision is not fundable from research support. This is in contrast to the more usual situation where faculty supervision of thesis work is a by-product of supervision of research projects. The Department is seeking means for funding the supervision of these foreign students' thesis work. The activity is judged important in that it introduces future international airline managers to US techniques and products. The foreign airlines provide a major market for US aircraft.

Research

Research conducted under the supervision of faculty in the Department was funded at $4.9 million for academic year 1980-81. This covers a wide range of activities in aeronautics, space, energy, and bioengineering, plus such miscellaneous activities as architectural aerodynamics, and the teaching of mathematics.

The Space Systems Laboratory has continued its intensive research on human productivity in space and on the assembly of large space structures, through the use of the Marshall Space Flight Center Neutral Buoyancy Facility (NBF). This program has developed to the point where the Laboratory has been invited to participate in a flight experiment using the Space Shuttle. They will substantiate the adequacy of the NBF in simulating space environment and study structural and assembly problems of space structures.
In addition, under a contract with the NASA Langley Research Center, the Laboratory is conducting research on the control of large, flexible space structures with particular emphasis on the application of modern control techniques to improve reliability. It also recently obtained a contract from the Aerospace Corporation to study the internal damping of such structures, with particular emphasis on joints.

This Aerospace Corporation contract is just one result of a concerted effort to obtain industrial funding for research. Another result is found in the Gas Turbine and Plasma Dynamics Laboratory, which negotiated a joint agreement with the Office of Naval Research and Rolls Royce, Inc. for support of work on turbine aerodynamics and cooling. The program is both theoretical and experimental. A Blowdown Turbine Facility will be designed and constructed for study of the aerodynamics and heat transfer in air-cooled turbines. An advanced minicomputer and array processor have been acquired which will enable detailed numerical computation of the viscous flow through turbines.

The Gas Turbine and Plasma Dynamics Laboratory also has substantial funding from Pratt and Whitney, General Electric Co., and Teledyne CAE for research on aircraft propulsion. This year, Associate Professor William T. Thompkins and Assistant Professor Alan H. Epstein, together with their students, completed a major program of flow measurement and computation in two advanced compressor stages. The information is being used for design of an improved compressor. The three-dimensional transonic computer program developed by Professor Thompkins is a key element in the program of advanced compressor design being developed by the NASA Lewis Research Center.

The Model Helicopter Research Group, under the direction of Professor Wesley L. Harris, Sr., has obtained new results on the characteristics of blade slap noise. A secondary slap phenomenon was observed with a pressure fluctuation opposite that of primary blade slap. A Mach number scaling law for such noise also has been found. Noise is a major problem with helicopters for commercial service.

Studies of transition and turbulent spots in two-dimensional channel flow, conducted in the Fluid Mechanics Laboratory under the direction of Professors Sheila Widnall and Marten Landahl, have yielded dramatic visualizations of the phenomena that occur in the transition from laminar to turbulent flow, including some strong waves that previously had not been seen.

From a combination of more precise experiments and a new theoretical approach, Visiting Professor Nicolas N. Garcia and Professor Leon Trilling have developed a more quantitative understanding of homogeneous nucleation in expanding water vapor than had been available in the past.

Associate Professor David Jansson and his colleagues in the Innovation Center have demonstrated the feasibility of a three-dimensional display system capable of displaying the image of an object in three dimensions so that it can be viewed from any direction. It has application to the display of data produced by various scanning methods used in medicine and oil surveying.

In the Man-Vehicle Laboratory, Professor Kenyon and Visiting Professor Yehoshua Zeevi have developed a research program on eye movement measuring systems. The work has application to pilot tracking behavior, pilot training, and visual system performance in general. This Laboratory has restructured its program of research on space sickness to be carried out in Spacelab, to compensate for deletion of the Sled experiment which was to have provided data on the effects of longitudinal acceleration. With the recent successful first launch of the Space Shuttle, this program is approaching fruition. It will be the Department's first experiment in space, and we hope it will be followed by many more.

The Wright Brothers Wind Tunnel has been used extensively for architectural aerodynamic studies of the Sears Tower in Chicago, the Hancock Building in Boston, and many similar projects. The tunnel has been underutilized relative to its potential for aeronautical research. However, recent suggestions from aircraft manufacturers in the Northeast have led to a feasibility study for refurbishing the tunnel to make it more attractive for research and development. It is one of the few closed return pressurizable tunnels located outside of NASA. As such, it has the potential for offering an extremely valuable high Reynolds number test capability. All tunnels with comparable characteristics are heavily used, and thus, have multiyear backlogs. The changes under consideration include reinstating the pressurization capability, adding a modern data acquisition system and, possibly, adding a Freon charging system which would extend the Reynolds number to a very high value.
School of Engineering

FACULTY

Appointments, Promotions, and Retirements

New appointments this year included: Edward F. Crawley, Boeing Career Development Assistant Professor, effective July 1, 1980. His interests are aircraft engine structures and space engineering. Joseph H. Haritonidis, whose appointment begins on July 1, 1981, will be an Assistant Professor in the field of experimental fluid mechanics.

Promotions which will be effective July 1, 1981 included: Wesley L. Harris, Sr., from Associate Professor with tenure to Professor of Aeronautics and Astronautics; Edward M. Greitzer, Associate Professor to tenured Associate Professor of Aeronautics and Astronautics; William T. Thompkins, Jr., from Assistant Professor to Associate Professor of Aeronautics and Astronautics; and Charles N. Oman, promoted from Principal Research Scientist to Senior Research Engineer.

Choon S. Tan was promoted from Postdoctoral Associate to Research Associate, effective December 1, 1980.

Professor Frank E. Marble of the California Institute of Technology was Visiting Hunsaker Professor for the spring semester. He participated in the research programs of the Gas Turbine and Plasma Dynamics Laboratory, and delivered the 17th Minta Martin Lecture entitled, "Unsteady Combustion in Aircraft Gas Turbines."

Dr. Hans von Ohain, former Chief Scientist of the Air Force Aeropropulsion Laboratory, now retired, and associated with the University of Dayton Research Institute, delivered the 18th Lester D. Gardner Lecture in October 1980. The title of the lecture was, "Pioneering in Jet Propulsion."

We were fortunate to have Professor Saul S. Abarbanel, Rector of Tel Aviv University, as Visiting Professor of Aeronautics and Astronautics. He worked in computational fluid mechanics, adding to the Department's growing expertise in this area.

Another Visiting Professor of Aeronautics and Astronautics this past year was Yehoshua Zeevi, who is on sabbatical from the Technion. He participated in a research program on the application of eye movement measurement and analysis to scan patterns in pilots with Professor Laurence Young in the Man-Vehicle Laboratory.

Professor Raphael Sivan of the Israel Institute of Technology, was Visiting Professor of Aeronautics and Astronautics during the summer of 1980. He worked with Professor Young in the Man-Vehicle Laboratory where he participated in research on the application of modern control theory to distributed systems and related biological problems.

Robert D. Hisrich, Associate Professor at Boston College, was Visiting Associate Professor of Aeronautics and Astronautics. He worked with Associate Professor David Jansson in the Innovation Center.

Professor Jack L. Kerrebrock requested and was granted leave effective July 1, 1981, to serve as Associate Administrator of the Office of Aeronautics and Space Technology at NASA in Washington, DC.

Professor James W. Mar, J.C. Hunsaker Professor of Aeronautics and Astronautics, was appointed Head of the Department effective July 1, 1981.

Honors

Professor James W. Mar and Professor John McCarthy were elected to the National Academy of Engineering in 1981. Professor McCarthy is on leave as Director of NASA Lewis Research Center. This brings the number of Course XVI faculty in the NAE to eight.

Professor K. Uno Ingard was awarded the Rayleigh Medal by the Council of the Institute of Acoustics in England.
An International Symposium on Hybrid and Mixed Finite Element Methods was held in Atlanta, Georgia, in April 1981, in honor of Professor T.H.H. Pian.

Professor Wallace E. Vander Velde was elected a Fellow of the American Institute of Aeronautics and Astronautics.

Professor Eugene E. Covert was designated University Educator of the Year by the American Society for Aerospace Education. He also was appointed chairman of the Propulsion and Energy Panel of AGARD.

Professor Sheila Widnall continued to serve as chairman of the MIT faculty.

Professor Jack L. Kerrebrock and Professor T.H.H. Pian were appointed honorary professors of the Beijing Institute of Aeronautics and Astronautics, Beijing, the People's Republic of China.

Dr. Charles Stark Draper received the Langley Medal which was established in 1908 by the Smithsonian Institute, and is presented for "especially meritorious investigations in the field of aerospace science."

JACK L. KERREBROCK

Department of Chemical Engineering

The Department achieved one of its most successful years ever in terms of accomplishments in its educational and research programs, recognition of faculty by prestigious awards, increased support for the Practice School and Professorships, and a strong spirit of confidence and leadership. Large enrollment and vigorous research activity place heavy demands on faculty and laboratory facilities. The Department still has the highest ratio of students to faculty of any department in the Institute, and the faculty continues to respond to these demands, maintaining our high standards of excellence.

Undergraduate Program

Undergraduate enrollment decreased to 319 students from the previous total of 335. A combination of lecture presentations and multiple recitation sections for core subjects accommodated the large classes and continued to provide effective student-faculty interaction. The following table shows the trends in undergraduate enrollment:

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<tbody>
<tr>
<td>Sophomore</td>
<td>103</td>
<td>107</td>
<td>98</td>
<td>107</td>
<td>99</td>
</tr>
<tr>
<td>Junior</td>
<td>97</td>
<td>106</td>
<td>114</td>
<td>111</td>
<td>109</td>
</tr>
<tr>
<td>Senior</td>
<td>51*</td>
<td>99</td>
<td>106</td>
<td>117</td>
<td>111</td>
</tr>
<tr>
<td>Total</td>
<td>251</td>
<td>312</td>
<td>318</td>
<td>335</td>
<td>319</td>
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* Does not include students in the five-year program who transferred to the graduate school.

The new curriculum for the Bachelor of Science in Chemical Engineering with additional specified requirements in chemistry, design, and economics, became effective in 1979-80. Most of the senior class took advantage of the new curriculum in selecting elective subjects.
Graduate Program

Graduate enrollment was 207 full-time students from the previous total of 228. Seventy-seven
students were enrolled in the doctoral program. Job offers for graduates at all degree levels
continued to be attractive. The following table shows the trends in graduate enrollment:

<table>
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<tr>
<th>Graduate Enrollment</th>
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<tr>
<td>Total Graduate Students</td>
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<tr>
<td>Graduate Students</td>
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<tr>
<td>Doctoral Students</td>
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</tbody>
</table>

Twenty-eight graduate students were enrolled in the Practice School this year. Students partici-
pated in project work at our Albany and Oak Ridge stations. The Albany station completed its
fourth year of operation under the sponsorship of the General Electric Company at its Silicone
Products Plant in Waterford, NY and its Noryl Plastics Plant in Selkirk, NY. The other station,
now in its 30th year of operation, is located in Oak Ridge, TN, and is hosted by Union Carbide's
Nuclear Division at Oak Ridge National Laboratory. Projects at the Albany station focus on
process improvement, development, and design in a number of polymer production operations.
At Oak Ridge, School of Chemical Engineering Practice studies involve synthetic fuels research,
nuclear fuel reprocessing, biochemical engineering, nuclear reactor safety, and controlled thermo-
nuclear fusion. By attending both stations, students are exposed to the practice of chemical
engineering utilizing group approaches to solving problems and developing communication skills.

Following the Visiting Committee's endorsement last year, a major effort was directed toward
providing financial support for the Practice School program. Two important goals were achieved
during the year. First, with the encouragement of John C. Haas (S.M. in Chemical Engineering
Practice, Class of 1942), financial support from the Phoebe W. Haas B Trust, and matching funds
from the Class of 1942, helped establish the Class of 1942 Chair. It will be used to support
the Cambridge director of the Practice School program for the first five years. Professor
Jefferson W. Tester now occupies that position. Second, the "Friends of the Practice School"
Committee, chaired by Jerry McAfee (Sc.D. in Chemical Engineering, Class of 1940), has
successfully secured a total commitment of $210,000 per year from 22 companies to provide
fellowship aid to Practice School students while they are taking classes in Cambridge. This
amount is in addition to the host company's support provided to the students while they are in
residence at the stations. As of May 31, 1981, the sponsoring companies of the program include
Air Products, Badger, Bechtel, Bonner and Moore, Dow Chemical, E.I. duPont de Nemours,
Ethyl Corp., Exxon, Gulf Oil, Halcon, Mobil Oil, NL Industries, PPG Industries, Republic Steel,
Rohm and Haas, Shell Oil, Standard Oil of California, Standard Oil of Ohio, Stone & Webster,
Sun Oil, Union Oil, and Wheelabrator-Frye. We continue to be strongly encouraged by the
support of the chemical and petroleum industry to maintain this educationally unique program
at MIT.

One of our major efforts during the year has been the recruitment of station director staff.
Visiting Professor Charles H. Byers of Polaroid Corporation was the Oak Ridge Station Director
during the year: Herbert Wood completed his second year as the Albany Station Director.
George Huff, a doctoral candidate in the Department, and Montgomery Alger (S.B. and S.M.
Chemical Engineering Practice, Class of 1978, and presently a doctoral candidate in chemical
engineering at the University of Illinois), have been recruited as the next Practice School
directors.

Requirements for the Master's Degree in Chemical Engineering Practice have been strengthened
to provide candidates with a more intense program in the core graduate subjects offered in the
Department. An active recruitment effort at other schools is underway to improve the program's
visibility nationwide, and to communicate its various attributes to qualified undergraduates who
might not be considering any graduate training. In order to increase the number of doctoral
students participating in the Practice School without disrupting the continuity of the Department's
research program, an extra session has been initiated to permit doctoral candidates to attend
the Practice School during the summer after they take the May qualifying examinations.
New Developments

Through the efforts of Ralph Landau (Sc.D., Class of 1941), the Bayer Professorship in Chemical Engineering was established by the Bayer Company of West Germany, one of the largest chemical firms in the world. The Chevron Professorship in Chemical Engineering was endowed by the Standard Oil Company of California, through the efforts of George M. Keller (S.B., Class of 1948). The Texaco-Mangelsdorf Development Professorship was jointly given by Frederick E. Mangelsdorf (S.M., Class of 1960) and the Texaco Foundation, through the efforts of Maurice F. Granville (S.M., Class of 1939) and Willis B. Reals (S.M., Class of 1947). A Joint Polymer Chair with the Department of Materials Science and Engineering was also established.

Four new faculty joined the Department. John F. Brady (B.S., University of Pennsylvania, Ph.D., Stanford), is spending a year as a postdoctoral fellow in Paris, studying fluid mechanics and polymer science. Fred Gelbard (S.B., MIT, Ph.D., Cal Tech), previously spent two years in research on aerosols at the Sandia Corporation. Herbert H. Sawin (B.S., Iowa State University, Ph.D., University of California at Berkeley), is involved with plasma chemistry and the manufacturing of large-scale integrated circuits. Jefferson W. Tester (B.S. and M.S., Cornell University, Ph.D., MIT), previously an assistant professor in the Department and later with the geothermal energy group of the Los Alamos National Laboratory, became Director of the Practice School.

Several distinguished scientists have visited the Department. Professor John Quinn, Chairman of Chemical Engineering at the University of Pennsylvania, spent part of his sabbatical year here. Dr. Frank Bovey of Bell Labs was the Dow Visiting Professor and taught a course in polymer chemistry based on his new book. Professor Hakuai Inoue of the University of Tokyo was a visiting professor, and presented a lecture on Japan's national effort on monocarbon chemistry, which he directs. Dr. Joseph L. Russell of Halcon International was a guest lecturer in applied chemistry. Dr. Wayne Erickson of the National Aeronautics and Space Administration was a visiting associate professor and taught the graduate course in thermodynamics.

Guest speakers for the fall semester included Dr. Ronald Thomas (Xerox Research Center), Professors Morton Denn and Arthur Metzner (University of Delaware), Professor Philip Walker, Jr., (Penn State University), and Professor Jerome Schultz (University of Michigan). The Warren K. Lewis lecturer was Professor Richard S. Stein of the University of Massachusetts. Spring semester seminars were presented by Professors Bruce Finlayson (University of Washington), James Carberry (University of Notre Dame), Dennis Hess (University of California at Berkeley), Alexis Bell (University of California at Berkeley), and Thomas Edgar (University of Texas). Dr. Louis Hegedus of W.R. Grace Research Division, Dr. Stanley Morris of International Coal Refining Co., and Dr. John Gland of GM Research Labs were also featured speakers.

FACULTY

Professor James Wei, Department Head, is a member of the Diesel Impact Studies Committee and a member of the Technology Panel for the National Research Council, which is involved in impact studies of diesel-powered automobiles. He is serving on the membership committee of the National Academy of Engineering to determine the selection of new members in the Chemical/Petroleum sections; he also served on the nominations committee to select candidates for the Council. He promoted university/industry cooperation by serving as a task force member of the Conference on Cooperative Advances in Chemical Sciences and Technology. He is on the American Institute of Chemical Engineering (AIChE) Steering Committee for Dynamic Objectives and the China Relations Committee. He is chairman for the Seventh International Symposium for Chemical Reaction Engineering to be held in Boston in 1982. He is Vice Chairman of a joint AIChE/Chinese Society of Chemical Technology meeting in Peking in 1982. He was the seventh MIT faculty to receive the William H. Walker Award of the AIChE for research publications. He was elected Fellow of the American Association for the Advancement of Sciences, and Fellow of the AIChE. He is editor-in-chief of Advances in Chemical Engineering, a publication of Academic Press. He also served on editorial boards of Industrial and Chemical Engineering, Process Design and Development, and International Chemical Engineering. He continues to be editor of the Chemical Engineering series of books for McGraw-Hill Book Company, as well as on the editorial boards of Chemical Technology and Chemical Engineering Communications. He has served on the
School of Engineering

visiting committee of the chemical engineering department at the Georgia Institute of Technology. Professor Wei presented seminars at SUNY-Buffalo, Carnegie-Mellon University, University of Pittsburgh, and Chevron Research Corporation, as well as Qinghua University at Peking and Shanghai Institute of Chemical Technology.

Professor Robert C. Armstrong gave invited lectures on the rheology of concentrated fiber suspensions at Sandia Laboratories and for the Society of Engineering and Science. He presented papers at the Society of Rheology meeting in Williamsburg, VA, at the AIChE meeting in Houston, and at the "Second Workshop of Numerical Methods for Viscoelastic Fluids" in Loch Lomond, Scotland. During August, he gave lectures at Universidad Nacional del Sur in Argentina on polymer rheology and polymer processing. While there, he advised the Ministry of Education on programs in polymer science and engineering.

Professor Janos Beér served on the Joint Committee (Board of Directors) of the International Flame Research Foundation (IFRF), and as Superintendent of Research, presented a paper on the long-term program of the IFRF at their meeting in Boston. He also served on the Science Advisory Board on Combustion Research of the Italian National Research Council and gave a seminar at their meeting in Ravera, Italy. He has been reelected as a member of the board of directors of the Combustion Institute, and gave an invited lecture to the American Physical Society on combustion fundamentals at Brookhaven National Laboratory.

Professor Robert A. Brown presented lectures on the role of convection in melt crystal growth at Langley Research Center, Lyndon Johnson Space Center, and Harvard University. He gave seminars on the mathematical theory of interfacial stability at Imperial College and University College of London. Professor Brown also took part in a special workshop sponsored by the University of Wales on numerical methods for simulating the flow of viscoelastic fluids.

Professor Robert E. Cohen served as coordinator of the MIT Polymer Seminar Series, as a member of the Internal Advisory Committee of the Center for Materials Science and Engineering, and as coeditor of the annual report on polymer research at MIT. He presented seminars at the Office of Naval Research, the University of Massachusetts, University of Lowell, Purdue University, Princeton University, University of Laval in Québec, at Xerox Corporation, and also at two MIT meetings.

Professor Clark K. Colton was appointed the Bayer Professor of Chemical Engineering. He assumed the responsibility of chairman of the Department's Graduate Admissions Committee, and he was appointed to the Search Committee for the new Dean of Engineering. He completed his term as director of the Food, Pharmaceutical, and Bioengineering Division of AIChE. He served as chairman of the membership committee of the American Society for Artificial Internal Organs (ASAIO), and he was elected to the executive committee of that organization. He served as consultant to a committee of the Food and Drug Administration concerned with hemodialysis standards. He continued to serve on the editorial board of the Journal of Membrane Science and as associate editor of ASAIO Journal. He gave invited presentations at the First International Conference on Glucose Sensors in Alexandria, Virginia, the Specialists Meeting on Hemodynamics and the Arterial Wall in Houston, the Conference on Advances in Fermentation Recovery Process Technology in Banff, Canada, the Symposium on the Evolution of Membranes in Biomedicine in Moscow, and the AIChE annual meeting in Chicago. He also presented a seminar at Syracuse University.

Professor William M. Deen was promoted to associate professor with tenure. He lectured on pharmacokinetics in a special summer course in toxicology at MIT, and presented a paper on hindered diffusion in small pores at the AIChE meeting in Chicago.

Professor Lawrence B. Evans was elected director of the American Institute of Chemical Engineers. He will serve for a three-year term. Professor Evans was an invited lecturer at Michigan State University and at the Chicago Section of the American Institute of Chemical Engineers.

Professor Fred Gelbard held the DuPont Assistant Professorship of Chemical Engineering. He presented a paper on simulating multicomponent aerosols at the winter symposium on Aerosol Systems and at the Nuclear Regulatory Commission. He was an invited speaker at the National Bureau of Standards Colloquium on Mathematical Modeling in Science and Engineering in which he presented numerical techniques for simulating aerosol systems.
Professor Jack B. Howard, Executive Officer of the Department, presented seminars at Brigham Young University, University of Kentucky, AVCO Everett Research Laboratories, and Exxon Research and Engineering. He gave invited lectures at workshops sponsored by the Electric Power Research Institute, the Environmental Protection Agency, the Gas Research Institute, and the Department of Energy. He presented papers at the Eighteenth International Combustion Symposium and the General Motors Research Symposium on Particulate Formation during Combustion. He was a member of the steering committee of the latter symposium and he became program chairman of the Nineteenth International Combustion Symposium to be held in 1982 in Haifa, Israel. He also served on visiting committees for the Institute of Mining and Minerals Research of the University of Kentucky, the Department of Fuels and Mining Engineering of the University of Utah, and the biomass conversion division of the Solar Energy Research Institute. Professor Howard is a member of the editorial advisory board of Combustion and Flame.

Professor John P. Longwell was appointed E.R. Gilliland Professor of Chemical Engineering. He served as chairman of the National Research Council’s Committee on Advanced Energy Storage and as a member of the Nuclear Regulatory Commission’s (NRC) ad hoc Committee on Alternative Aircraft fuels as well as the NRC Energy Engineering Board. He also served as a member of the NASA Propulsion Advisory Committee. Invited presentations included a discussion of the Petroleum Outlook for the NRC Aeronautics and Space Engineering Board and a discussion of the Control of NOx and SOx for the joint Harvard/MIT Environmental Science Seminars. Professor Longwell wrote a chapter, "Fuel Science and Technology," for the NRC Outlook for Science and Technology, and prepared a special set of lectures on the interface between fuels and combustion for the Exxon Technical Education Program.

Professor Michael Manning was promoted to associate professor. He gave the Annual Sigma Xi Lecture at Worcester Polytechnic Institute summarizing research in the area of astronaut life-support systems. He gave an invited lecture at General Motors Research Laboratory on carbon deposition on group VIII metal catalysts.

Professor Edward Merrill was an invited lecturer at the Centre de Recherches sur les Macromolecules, Strasbourg, France; Battelle Memorial Institute; Sandia Laboratories; and at a meeting of the ASAIO.

Professor Michael Modell is currently on leave of absence to start a new company and develop and commercialize a new technology which is based, in part, on his earlier MIT research. His research in the 1970s on reforming organics in supercritical water led to a patent granted in 1979 which was assigned to MIT. The new company has licensed that patent, and the Institute has accepted an equity interest in the company.

Dr. C. Michael Mohr, senior lecturer, continued his work with the Center for Advanced Engineering Studies in the area of continuing education. Work accomplished included the translation of several case studies in energy conservation into modules for computer-aided instruction and the implementation of these modules on a large scale commercial computer network.

Professor Frederick A. Putnam was promoted to Associate Professor of Chemical Engineering. He was reelected to serve as secretary to the Gordon Conference on Chemistry of Interfaces. He cochaired a session at the 73rd annual meeting of the AIChE entitled "Fundamental Processes in Heterogeneous Catalysis."

During the past year Professor Adel Sarofim presented seminars at the State University of New York at Buffalo, Worcester Polytechnic Institute, Princeton University, and the University of Minnesota; presented papers at the Eighteenth Symposium on Combustion, the EPRI-EPA Joint Symposium on Stationary Combustion NOx Control, the DOE/West Virginia University Conference on Fluidized Bed Combustion, the AIChE Annual Meeting, ACS/IEC Winter Symposium on Aerosol Systems, and participated in short courses on Industrial Aerosols at UCLA and on Aspects of Coal Combustion at the University of Minnesota. He was coauthor with W.S. Blazowski and J.D. Keck of a paper which received the 1980 Beat Paper Award presented by the ASME Combustion and Fuels Committee.

Professor Charles N. Satterfield was the first MIT recipient of the R.H. Wilhelm Award of the American Institute of Chemical Engineers for "distinguished and continuing contributions to chemical reaction engineering." He was the keynote speaker at the 7th Canadian Symposium on Catalysis/30th Canadian Chemical Engineering Conference. He presented a research paper on Fischer-Tropsch synthesis at the annual meeting of the AIChE and gave lectures on Fischer-Tropsch
synthesis at the Philadelphia Catalysis Club, Mobil Research and Development Corporation, Montedison in Milan, Italy, and Royal Dutch Shell and Akzo Chemie in Amsterdam. He lectured at the Swiss Federal Institute of Technology in Zurich. His book, Mass Transfer in Heterogeneous Catalysts, was singled out by the publishers of the Citation Index as one of the most frequently cited publications in its field, and it has been reprinted and is now available from the Krieger Publishing Company.

Professor Herbert Sawin held the DuPont Assistant Professorship of Chemical Engineering. He gave invited lectures at a New England Catalytic Society meeting and the Digital Equipment Corporation. He developed a new course on integrated circuit processing for chemical engineers.

Professor Kenneth A. Smith became Associate Provost of the Institute. He remains active in research in the Department.

Professor Jefferson Tester held the Class of 1942 Chair in Chemical Engineering Practice and was promoted to associate professor with tenure. He was awarded the outstanding chemical engineer award in 1980 for his work in geothermal technology by the New Mexico Chapter of the American Institute of Chemists. He served as a technical advisor to the US/Federal Republic of Germany Joint Steering Committee of the International Energy Agency on the Development of Hot Dry Rock Geothermal Resources. He gave seminars on various aspects of geothermal reservoir engineering at Stanford University, University of California at Berkeley, and Oak Ridge National Laboratory. Professor Tester also presented a paper reviewing the progress of the experimental field program and reservoir modeling work at Los Alamos at the Third Information Conference on Hot Dry Rock Geothermal Development in Santa Fe, New Mexico.

Professor Costas G. Vayenas held the J.R. Mares Assistant Professorship of Chemical Engineering and was promoted to associate professor. He was the coordinator of the Departmental seminar series and gave invited lectures at Tufts University, Celanese Co., E.I. duPont, Yale University, University of Houston, Brandeis University, and Exxon. He was also an invited speaker at the Gordon Research Conference on Chemistry of Interfaces.

Professor Preetinder S. Virk gave invited lectures at the State University of New York, the University of Rochester, and Tufts University. He presented papers at two American Chemistry Society national meetings and he participated in a Fuel Chemistry Division Symposium. He also presented talks at Stone & Webster Engineering Corporation, the Eastman Kodak Research Laboratories, and the Oak Ridge National Laboratory.

Professor Glenn C. Williams continued to serve as Graduate Registration Officer for the Department, and he was chairman of the Subcommittee on Graduate Subjects of Instruction of the Committee on Graduate School Policy for the Institute. He was also a member of the admissions committee for the Center for Advanced Engineering Studies. He received the 1980 Sir Alfred C. Egerton Medal of the Combustion Institute for "distinguished, continuing, and encouraging contributions to the field of combustion." He is a member of the board of directors of the Combustion Institute and serves on the international editorial board of Fuel and on the editorial advisory board of Combustion and Flame.

Student Awards and Honors

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 Steven F. Karel. The American Institute of Chemists Award, offered to a senior in chemistry and/or chemical engineering who displays outstanding promise, was also awarded to Steven Karel. The American Institute of Chemical Engineers Annual Scholarship Award was given to junior Gregory Dow. The Chevron Undergraduate Scholarship, presented for outstanding academic performance in the Department and for high professional promise as a chemical engineer, was awarded to Edward Ascoli. The Chemical Engineering Special Service Award, presented in appreciation of unselfish contributions to the success of Departmental activities, was given to graduate student Thomas Hastings and undergraduate student Suzanne Majerus. The Robert T. Haslam Cup was awarded this year to Daniel J. Halbert in recognition of outstanding professional promise in chemical engineering. Rhonda J. Schaefer was awarded an Eastman Kodak scholarship.
RESEARCH

The research volume of the Department was approximately $1.9 million, compared to $1.8 million in 1979-80 and $1.7 million in 1978-79. When interdisciplinary research activity, for which Department faculty are responsible is included, the volume was approximately $5.4 million compared to $5.0 million in 1979-80 and $4.9 million in 1978-79. The Department's research extended over a wide range of activities with energy and fuel projects, reactor performance studies, polymer studies, and biochemical and biomedical research accounting for the major portion.

Professor Armstrong supervised research on fundamentals of non-Newtonian fluid mechanics and applications to polymer processing. Concentration of effort in this research has fallen in two general areas: rheological properties of filled polymers, with particular emphasis on constitutive modeling and structure/property relationships, and numerical simulation of viscoelastic fluid flows. Of particular interest in this research is a constitutive equation for describing the flow of highly filled fiber suspensions which has been obtained by structural arguments. This result allows, for the first time, an assessment of the interaction between flows of fiber suspensions and the local distribution of orientation of the fibers. Also a rheological equation of state has been found which describes flow of carbon-black-filled elastomers over a wide range of structural variables.

Research -- using the MIT Combustion Research Facility -- has continued under the direction of Professor J.M. Beér. Research was conducted on the control of emissions of polycyclic aromatic hydrocarbons and nitrogen oxides by combustion process modification when burning synthetic, coal-derived fuels in turbulent flames. Based on these experimental studies, a design strategy for combustion process modification was developed in the Combustion Research Facility for low emissions of nitrogen oxides and organic particulates from coal-derived fuel flames.

Fluidized coal combustion experiments were carried out using the 500KW pilot plant fluidized combustor to better understand the formation and growth of bubbles in large particle fluidized beds, and the reactions that occur in the freeboard of the fluidized combustor.

Professors Sarofim and Beér have continued their contributions to the modeling of fluidized combustion of coal and the processes of nitrogen oxides, carbon monoxide, and particulates emission, as well as investigations of the combustion of pulverized coal particles and inert pyrolysis of liquid fuel droplets.

Professor Brown continued research into the fundamentals of the growth of single-crystal materials from the melt. New numerical methods were developed for studying the interaction of convection in the melt, melt/solid interface shape, and the segregation of dopants and impurities in the crystal. These techniques are being applied to a detailed study of directional solidification. Professor Brown also continued research on the fundamentals of interfacial stability with work focusing on the fluid mechanics of spherical liquid shells. Another study, supervised in collaboration with Professor Armstrong, dealt with new methods for the numerical simulation of non-Newtonian flows.

Collaborative research by Professors R.E. Cohen and R.F. Baddour has led to the issuing of a patent on a novel process for fluorinating polymer surfaces. The patented method employs dilute mixtures of fluorine gas in helium, and a cold plasma discharge, to transform surfaces of commodity polymers into materials which in many ways resemble expensive and difficult-to-process fluoropolymers.

Research on block copolymers and polymer blends led to a unified picture of the regimes of molecular weight and composition for which homogeneous or heterogeneous mixtures are to be expected. Also in the area of block copolymers, Professor Cohen has been collaborating with faculty colleagues in Mechanical Engineering (Professor A.S. Argon) and Nuclear Engineering (Dr. C.V. Berney). In the latter project, extensive use has been made of the small angle neutron scattering facility at Oak Ridge National Laboratory. Professor Cohen's laboratory's anionic polymerization capabilities, which enable his research group to produce well characterized model macromolecular compounds, have earned him a central role in the collaborative efforts.

In the area of nonisothermal viscoelasticity, important advances were made in the application of the "creep T-jump" experiment to a class of nonlinear viscoelastic materials -- carbon filled elastomers. Similar considerations of nonlinear, nonisothermal viscoelasticity led to a collaborative publication with researchers from Sandia National Laboratories on the subject of physical aging in glassy polymers.
Professor Colton, in collaboration with Dr. William Chick of the Joslin Research Laboratory, Harvard Medical School, continued experimental and theoretical research related to the development of a hybrid artificial pancreas consisting of pancreatic beta cells cultured on the exterior surface of semipermeable tubular membranes. A new study was initiated in collaboration with Dr. J. Stuart Soeldner of the Joslin Laboratory to develop physiological models of glucose metabolism to permit testing of new forms of insulin therapy for diabetics. Professors Colton and Smith, in collaboration with Professor Michael B. Stemerman of the Beth Israel Hospital, continued research on the transport of low density lipoproteins in the arterial wall and its relationship to atherogenesis. New methods were developed for analysis of data from quantitative autoradiography experiments, and models were developed to account for simultaneous transport and metabolism of lipoproteins in the arterial wall.

Professor Deen continued research dealing with transport processes in the kidney, leading to a quantitative model of protein filtration across normal and injured capillaries that is intended as an aid in clinical diagnosis. Research on hindered transport in small pores led to new experimental and theoretical results concerning electrostatic double layer interactions between permeating solutes and pore walls. In collaboration with Professor Steven Tannebaum of the Department of Nutrition and Food Science, a preliminary pharmacokinetic model of nitrite and nitrate was developed, as part of an effort to assess the health risks associated with formation of nitrosamines and related carcinogens in the body. A new project was undertaken dealing with mass transfer phenomena in electrochemical processes for integrated circuit fabrication.

Professor Evans's ASPEN (Advanced Systems for Process Engineering) Project has been underway at MIT since 1976 to develop a computer-based simulator and economic evaluation system. The 250,000-line software system will simulate the flowsheet of a proposed or operating plant. In addition to detailed heat and material balances, it can also provide preliminary estimates of capital and operating costs and economic viability. The project has been funded by the US Department of Energy for use in evaluating process alternatives for synthetic fuels. The ASPEN system has been delivered to more than 50 companies and the system is now in use at government laboratories and energy technology centers. The project is scheduled for completion in the fall of 1981 when the system will be delivered to the DOE and will then be publicly available.

Professor Evans and the ASPEN staff extended the ASPEN cost estimation and economic evaluation system to handle nuclear facilities. The work involved extending the costing methodology to account for the many factors that result in increased cost of nuclear facilities compared with fossil energy processes.

ASPEN was also used to model synthetic fuel processes including coal gasification, coal liquefaction, and oil shale processing. It also has been used to model systems with electrolytes, such as the Benfield process for acid gas scrubbing. A model also is being developed of the Bayer process for recovery of alumina.

Professor Evans and Professor D.I.C. Wang of the Department of Nutrition and Food Science continued their research on the dynamics and control of industrial fermentation systems. They are presently working to exploit a new sensor, called a filter probe, that can monitor cell biomass concentration and morphology during fermentation. A goal is to develop improved methods for control and optimization of penicillin fermentation.

Professor Gelbard initiated research on the development of an electrodynamic balance to levitate and weigh single particles less than a micron in diameter. The device consists of a quadrupole of revolution and the particle mass is determined by measuring the gravity balancing voltage before and after the removal of an electron. The device will be used to study atmospheric aerosol particles growing by heterogeneous reactions with pollutant gases. The goal is to determine the mechanisms for pollutant particle gas-to-particle conversion.

Professor Howard continued basic studies of coal pyrolysis and hydropyrolysis, with a focus on catalytic effects of minerals and inorganic elements naturally occurring in the coal and of other inorganic compounds added to the coal. Improved understanding of the effects of process conditions on product yields was pursued by mechanistic studies of mass transfer in molten coal particles and secondary reactions of primary coal pyrolysis products. Professor Howard also studied the burnout of soot particles in flames in collaboration with Professor Sarofin, and with Professor Longwell he studied the roles of hydrocarbon intermediates in flames in the formation of engine deposits and the emission of soot and polycyclic aromatic hydrocarbons.
Professor Longwell has completed studies of fluidized bed pyrolysis of coal and lignite in the presence of calcium oxide. Observed reductions in the yield, oxygen, and polynuclear aromatic content of the tar are now being investigated by studies of pure compound pyrolysis over calcium oxide. This work has also been extended to study of fluidized bed pyrolysis of oil shale. In this case, yield loss is less severe because of the relatively low polynuclear aromatic content.

Professors Howard and Longwell are extending the study of pyrolysis of wood components to lignite, hemicellulose, and whole wood in order to determine the source and kinetics for formation of wood pyrolysis products. Professors Howard and Longwell are also studying the formation of polycyclic aromatics in premixed fuel-air systems using a flat flame burner and a well-stirred reactor. The similarity of composition of the polycyclic aromatic hydrocarbon (PCAH) mixture for fuels as diverse as ethylene and toluene indicates that these compounds are built from similar pyrolysis fragments from the original fuel.

Studies of soot and polycyclic aromatic formation in the rich core of a turbulent diffusion flame, carried out in the Sloan Laboratory burner by Professor Longwell, have demonstrated local conversions of diesel fuel to soot as high as 60 wt percent. Relatively small amounts of polycyclic aromatics are formed, indicating that soot and polycyclic aromatics can be formed at different locations in practical flames. This trend was confirmed in studies of emissions from domestic oil burners where PCAH emissions actually increased as smoke was decreased by burner adjustment.

Professors Sarofim and Longwell are studying the interaction of fixed nitrogen compounds with soot in rich flames typical of staged combustion systems for NOx control. It is believed that these reactions play an important role in controlling the effectiveness of this technique.

Professors Longwell and Sarofim are initiating a new program on the fluidized bed combustion of spent oil shale. The interaction with calcination of the calcium and magnesium carbonates in the stone is important in the design and operation of advanced retorting systems since the large amount of heat absorbed in carbonate decomposition can negate the recovery and use of heat from the combustion of the char left on stone after oil recovery.

Professor Manning continued research with Professor R.C. Reid in the area of astronaut life support systems. Professor Manning initiated research on the catalytic oxidation of chlorinated hydrocarbons for EPA. The study is aimed at developing processes and catalysts for the proper disposal of toxic waste from the organic chemicals industry.

Professor Merrill extended his previous studies of model networks formed by reaction of end-linking silicones, and showed the importance of loose-ended chains in reducing the equilibrium tensile modulus to values predicted by the Langley-Graessley theory of trapped entanglements. He prepared a new class of hydrophilic biomaterials based on polyethylene oxide as the "soft-segment" of a segmented polyurethane in which the hard segment was prepared from 1,4 cyclohexane diisocyanate (CHDI). These materials show strikingly better properties than those based on aromatic diisocyanates. In particular, phase separation is more complete. Professor Merrill and his group extended their use of X-ray photoelectron spectroscopy (XPS-ESCA) to show that these new polyurethanes contain less nitrogen and more polyether in the surface layer than any other so far studied.

During the last year, Professor Modell has developed a new supercritical process for the destruction of toxic and hazardous wastes. The overall effect of the process is to convert organic substances to carbon dioxide and inorganic salts with or without the recovery of energy in the form of high-temperature, high-pressure steam. Halogenated organics, organic phosphorus, organic sulfur, and organometallics are solubilized in supercritical water (SCW) and subsequently destroyed. Heteroatoms are recovered as innocuous solid salts. Destruction efficiencies of 99.99 percent or greater have been achieved with wastes containing PCBs, DDT, Lindane, and chlorinated dioxins. All reactions are carried out in a closed system where all of the resulting vapors, liquids, and solids are environmentally acceptable and require no pollution control equipment.

Professor Putnam began a research program in the colloid chemistry of oil spills. This study will elucidate the physical chemical mechanisms operating during the interaction of sea sediment with dispersed oil droplets. This interaction can lead to the incorporation of spilled oil in marine sediment, which the research seeks to minimize due to a spill's adverse environmental effects.
Professor Putnam continued research in the surface chemistry of hydrodesulfurization catalysts. The surface site energy distribution of molybdenum disulfide, the active ingredient in hydrodesulfurization catalysis, was measured and related to its chemical activity as a catalyst. Contrary to expectation, the catalytic activity of molybdenum disulfide was not proportional to the surface area of active "edge" sites on the crystallites.

Professor Putnam continued research in the surface chemistry of catalytic reforming on platinum. A reactor which combines atmospheric pressure reaction rate measuring capability with ultra-high vacuum surface analytical techniques (Low Energy Electron Diffraction, Auger Electron Spectroscopy, X-ray Photoelectron Spectroscopy) was built and tested. This reactor is being used to relate the catalytic selectivity for various types of hydrocarbon reactions to the geometric and electronic structure of the catalytic site.

Professor Sarofim has participated with Professors Longwell, Bér, and Howard in a comprehensive program on fuel utilization. The research consists of theoretical and experimental studies of the combustion of solid, liquid, and gaseous fuels under conditions covering those encountered in fluidized bed combustors, conventional pulverized coal-fired boilers, and MHD combustors. A significant fraction of the effort is devoted to the understanding of factors governing the formation and reduction of atmospheric pollutants including polycyclic aromatic hydrocarbons, soot, SOX, NOX, and inorganic particulate.

Professor Satterfield continued studies of a liquid-phase slurry Fischer-Tropsch synthesis process accelerated during the past year. Attention is being directed to determination of the intrinsic kinetic behavior in the presence of a liquid for comparison with vapor phase kinetics, mass transfer effects, and modeling of industrial-type bubble column reactors. Especially noteworthy is the finding that on a potassium-promoted iron catalyst, representative of that used industrially, the distribution expressed as mole fraction of product of carbon number N versus N followed precisely the Flory distribution relationship over a wide range of conversions and H2/CO ratios, and over nearly five orders of magnitude of the mole fraction. This indicates that all products of one carbon number, whether isolated as olefin, paraffin, oxygenate, etc., stemmed from a common precursor.

Professor Satterfield continued studies of catalytic hydrodenitrogenation (HDN) on a commercial NiMo/Al2O3 catalyst using quinoline as a model compound and with various reaction intermediates. Water vapor, as would be formed in hydrotreating a feedstock containing oxygenated compounds, was found to have little net effect on the overall HDN rate under representative vapor-phase industrial processing conditions. The marked enhancing effect on H2S on the HDN reaction rate is not significantly affected by moderate amounts of water vapor. Newer studies are being performed with an improved laboratory-scale trickle bed reactor.

Professor Sawin has developed a research program in reactive ion etching of silicon for integrated circuit processing. His studies center on the kinetic etching rate enhancements caused by ionic bombardment. This work is partially funded by a grant obtained from Digital Equipment Corporation. He also has developed a research program to study the surface kinetics of the chemical vapor deposition of silicon.

Professor Senkan continued his research studying the combustion characteristics of chlorinated hydrocarbons (CHCs). Using specially built burner systems, individual CHC compounds and mixtures of select CHC compounds were examined in order to develop a better understanding of the scientific principles involved in toxic chemical waste combustion. In collaboration with Professor Manning, low temperature catalytic combustion characteristics of chlorinated hydrocarbons were also studied.

Professor Tester continued his studies of transport of heat and mass in fractured/porous rock reservoirs used for geothermal energy extraction. Two major areas were examined this year. The first dealt with the interpretation and numerical modeling of fluid dispersion as measured by tracer testing of the field reservoir at Fenton Hill, New Mexico. The second area was concerned with the dissolution and reprecipitation of minerals and displacement of saline fluids contained in the fractured/porous rock system at Fenton Hill. A combined program of laboratory kinetic and equilibrium measurements coupled to theoretical and numerical simulation studies is being developed to interpret and predict geothermal reservoir performance.
Professor Costas Vayenas supervised research on a new fuel cell concept in which ammonia is
electro-oxidized to nitric acid with simultaneous production of electrical energy. He also supervised
a project on the use of solid electrolytes to study the mechanism of partial catalytic oxidations
and to enhance electrocatalytically their selectivity to valuable products, and a project on the
theoretical and experimental investigation of chemical oscillations.

Professor Virk studied the reaction pathways involved in thermal processing of coal and biomass,
with special focus on hydrogen transfer reactions associated with coal liquefaction and the modeling
of pathways for lignin thermolysis. He studied the mechanism of drag reduction by macromolecular
solutions in turbulent pipe flow using collapsed and extended polyelectrolytes, with a view to
discerning equivalences among these additives. He collaborated with Professors Smith and Reid
in experimental and theoretical research on the dynamics of LNG storage tank response to
atmospheric pressure fluctuations, with a view to enhancing the safety of above-ground LNG
storage.

Professor Wei supervised research on the catalytic hydrodemetallation process for the removal of
metallic components from residual fuel oils, using autoclave and continuous high pressure fixed-
bed reactor techniques. The reaction involves a consecutive mechanism, and the intermediate
species has been isolated. 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. He started research on the conversion of methanol to the petro-
chemical feedstocks olefins and aromatics through the zeolite catalysts (ZSM-5). He has also
begun research on the optimal size of a chemical plant under uncertainties of market demand,
price, raw material availability, new technologies, and governmental interventions.

JAMES WEI

Department of Civil Engineering

The decade of the 1980s is a period of great opportunity for the Civil Engineering profession in
general and for the Department in particular. Recent articles in such magazines as Business Week
and Fortune have focused on such issues as the boom in construction, need for control in toxic
wastes, natural resource development, energy-related construction (e.g., synfuels), and have
noted the substantial undersupply of civil engineers. In addition, more general notions such as
the "reindustrialization" of America and the need to improve productivity, broadly defined, have
many implications for civil engineering research and education. Rebuilding America's civil infra-
structure, from both a physical and an institutional perspective, is a powerful and important
theme as is infrastructure development abroad. The Department, with its existing strengths in
physical systems, economic and system analysis, and its growing strength in management and
institutional studies, is uniquely positioned to work and lead in these areas. The Department
sees the next several years as a unique opportunity to educate a new generation of civil engineers
to do research and to practice in areas of long-term importance for the nation and the world, and
for the Department to evolve by building on current strengths while adding capabilities in new
cross-cutting areas.

Undergraduate Education

The Department's new undergraduate program began its first year of operation in 1980-81, and
the Department welcomed the first class of sophomores who will participate in this newly structured
and innovative curriculum in Civil Engineering. The key element of the undergraduate curriculum
is the Undergraduate Core Program. This group of four subjects provides a technical foundation
for the entire academic program. Basically, the four subjects (two each semester) are intended
to be taken in a single year by all Civil Engineering undergraduates, usually in their sophomore
year.
In subjects 1.02 and 1.03 (offered in the fall and spring terms, respectively), students are taught the fundamentals of engineering systems analysis, including methods of optimizing designs, probability theory, and statistics. The parallel two-semester sequence of subjects 1.04 and 1.05 covers the analysis of the basic physical processes which are fundamental to civil engineering, including both solid and fluid mechanics.

The most innovative aspect of this core program is its stress on achieving a synthesis of the different aspects of engineering. Once each week, all students in the program meet for a special session, taught by the core program director, Professor Robert Whitman. This meeting period is used to acquaint undergraduates with the breadth of civil engineering activities and to apply the methods developed in the lectures and problem sets to realistic design problems. Activities this year have included site visits to Harvard Square where tunneling for the extension of the Massachusetts Bay Transportation Authority's Red Line is taking place and to the construction site of MIT's new undergraduate dormitory on Memorial Drive. Faculty from each of the Department's three divisions (Transportation, Water Resources and Environmental Engineering, and Constructed Facilities) have lectured to the core program students about the types of civil engineering careers within the scope of their divisions. Finally, students have participated in "mini-projects" as diverse as the analysis of alternative highway routes, the optimization of structural elements in a hang glider, the design of a bridge span under highly variable loads, and the planning of a reservoir for flood control.

After taking the core program, students in the Department then select an area of specialization from the programs offered by each division of the Department. These advanced options (currently three in number) are specifically designed to build upon the undergraduate core, and hence the instruction in advanced subjects depends upon a common knowledge base, regardless of the area of specialization.

Student reaction to the undergraduate core has been enthusiastically positive. The subjects have been very well organized and taught by Professors Whitman, Steven Lerman, David Marks, Keith Stolzenbach, and Hilary Irvine. Also, the fact that the entire sophomore Civil Engineering class has this common experience has helped develop a visible spirit among these students, which, we hope, will carry through the junior and senior years.

While the Department is optimistic about these positive steps in the undergraduate program, the fact remains that the undergraduate enrollment in Civil Engineering has experienced a steady decline over the last five years. Undergraduate enrollment is down about 39 percent from 1976, the postwar peak year. (However, the Department is increasingly attractive to women students, with 30 percent of our current undergraduates being women.)

We are quite hopeful about reversing our enrollment erosion over the next several years and are taking steps to achieve this. First, we are confident that our new undergraduate program, a very rigorous and challenging curriculum, will prove attractive to MIT undergraduates. Second, we believe that the spirit exhibited by the past year's sophomore class will translate into more visibility for the Department among undergraduates. Third, we are working particularly hard to provide an effective environment for undergraduates in the Department. We have established an undergraduate complex on the first floor of Building 1 -- housing some of the faculty involved in undergraduate teaching, two graduate instructors who assist in teaching the undergraduate core, and a conference area for faculty/student interaction. We have refurbished some of the undergraduate laboratories in Building 40 for the teaching of 1.106 Laboratory Projects in Aquatic Systems: Physical Aspects and 1.107 Laboratory Projects in Aquatic Systems: Chemical and Biological Aspects. Our UROP program is an active one, and the student chapter of the American Society of Civil Engineers and Chi Epsilon (the Civil Engineering honor society) provide a focus for student activity. In an attempt to make students aware of the opportunities and challenges in Civil Engineering, we published a newsletter (and will continue this into next year), emphasized publicity for our Departmental Freshman Open House, and will offer four undergraduate seminar subjects next fall.

The faculty sees a viable and innovative undergraduate program as a priority and as a responsibility of a Department that prides itself on a leadership position in the profession.
Department of Civil Engineering

Graduate Program

The graduate program of the Department continues to stress the wide-ranging interest of our faculty and students. A number of our graduate students participate in Departmental programs such as geotechnical engineering, construction engineering, project management, structural engineering and mechanics, transportation, hydrodynamics and coastal engineering, hydrology and water resource systems, water quality control, aquatic environment, and environmental engineering. In addition, many of our students and faculty participate in interdisciplinary graduate programs and activities throughout the Institute. For example, we are active in the S.M. program of the Center for Transportation Studies (CTS), the S.M. program in Technology and Policy, the S.M. program in the Management of Technology, the Joint MIT-Woods Hole Oceanographic Institution (WHOI) Program, the Mining and Minerals Resources Institute, the Operations Research Center, the Technology Adaptation Program, the Energy Laboratory, Sea Grant College Program, and the Joint Center for Urban Studies of Harvard and MIT, among others.

In fact, participation in a variety of such activities has long been a hallmark of the Department. Many of our faculty play leadership roles in these programs and make a major contribution to the intellectual growth of the Institute as well as to the Department. Among our faculty participating in these programs are the following:

Professor D. Roos, Director, Center for Transportation Studies
Professor F. Moavenzadeh, Director, Technical Adaptation Program
Professor R. de Neufville, Chairman, Technology and Policy Program
Professor D.R.F. Harleman, Faculty Coordinator for Environmental Management, Energy Laboratory
Professor W. Melville, Faculty Coordinator, Energy Laboratory
Professor S. Chisholm, Member of Joint Committee on Biological Oceanography, WHOI
Professor O. Madsen, Member of Joint Committee on Oceanographic Engineering, WHOI
Professor P.S. Eagleson, Member of the Committee on the Sea Grant College Program
Professor K. Stolzenbach, Faculty Research Director, Sea Grant
Professor N. Wilson, Chairman, Master of Science in Transportation Standing Faculty Committee, Center for Transportation Studies
Professor O. Buyukozturk, Member of the Committee on the Sea Grant College Program

We will continue to urge our faculty to play these leadership roles, while recognizing that at the same time the educational offerings of the Department must be effectively maintained and developed.

The size of our graduate program continues to grow. Graduate enrollment figures since 1976-77 are as follows:

Graduate Enrollment

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The enrollment in the past year was the highest in our history. It is a reflection of the broad nature of the program described above; the continued strength of international interest in Civil Engineering; the strength of several new activities, particularly the program in Construction Engineering and Project Management; the Technology and Policy Program; and the Aquatic Research Group. Also, some of the recent growth can be attributed to a larger fraction of our graduate students (mainly among foreign students) deciding to stay for doctoral degrees. Thus, the number of years in residence per student is growing steadily. The faculty feels that the program is somewhat too large, and steps to reduce the incoming class size by about 30 percent were carried out this past year. However, given the shift to doctoral study noted above, the impact of this strategy on total number of students will be modest for the 1981-82 academic year.

In cooperation with the Writing Program of the Department of Humanities, the Department will institute a writing competency requirement for all graduate students. All students will take a diagnostic examination, and based upon the results of this, may be required to take a remedial subject or short course. This will be mandatory effective with the incoming class of September 1982. In September 1981, the exam will be conducted on an optional basis. This new requirement is an affirmation of the Department's sense of the importance of communication skills in the education of an engineer, and, in fact, is the first new Department-wide graduate requirement introduced in many years.
There were several new graduate subjects developed by the Department's faculty. Among these are a subject in Traffic Engineering (1. 209) by Professor Yosef Sheffi; a major revision of 1.413 Design-Construction Interface; a new subject, Learning from Construction Failures (1.421); and a major revision of 1.431 Structuring Construction Industry Organizations, all by Professor Henry Irwig. Professors Robert Logcher and David Ashley developed a new subject, Evaluation and Financing of Development (1.481). Dynamics of Stratified Fluids (1.64), offered by Professor Wallace Melville, has undergone substantial revision, and Professor Peter Eagleson has developed a new subject in Engineering Hydrology (1.713) to be offered in the spring of 1982.

RESEARCH

The Department's research activities continue to be a vital element of its program. Our faculty views research together with our academic offerings as forming our overall educational program.

Our research volume continues to grow at a rate that is characteristic of the last 20 years. Our current annual research volume (including research performed by Department faculty and staff through interdepartmental laboratories and centers) is in excess of $8 million. Our research budget has grown by 75 percent in real terms over the past decade. The Department is among the most highly leveraged at the Institute, with a ratio of research budget to academic budget of close to 5:1. Research funding has permitted us to develop junior faculty, to support substantial numbers of graduate students as research assistants, and to develop a talented cadre of research staffers who contribute to our academic programs as well.

The above notwithstanding, the research funding environment for the immediate future is far from certain. A large fraction of our research funding is governmental in nature (Federal, state, and local), and it seems clear that, in general, there will be a substantial diminution of such support. However, which areas will be cut is not yet clear, and quite possibly, certain areas of Department interest may survive unscathed. Given the uncertainties, the Department was particularly conservative in making commitments for financial support to incoming graduate students for the 1981-82 academic year. Twenty-two incoming students were offered support, as compared with 53 and 56 the two previous years.

The Department has taken steps to ensure continued research support. Among these are the aggressive development of areas of interest to the Department in which Federal interest is likely to continue (e.g., water quality), substantial activity in the development of overseas research opportunities, and a redoubling of our long-term effort to establish effective research relations with private industry, and in particular, with the construction industry. Our efforts to establish a Departmental Center for Construction Research and Education are described elsewhere in this report.

The scope of our current research continues to be quite broad, including areas such as offshore engineering and exploration, earthquake engineering, risk analysis, concrete nuclear structures, materials behavior, tunneling, soil-structures interaction, soil behavior, frozen soils, dam safety, thermo-mechanical behavior of roofing systems, transportation demand analysis, rail operations, energy contingency planning, transit planning and management, automobile tire industry, land use/transportation interaction, highway cost allocation, use of microcomputers in transportation systems analysis, hydrodynamics of ocean waves, sediment transport thermal discharge effects, ocean thermal energy conversion, stability of solar ponds, water allocation for energy development, water master plan developments, reservoir operation, landsurface hydrology, subsurface water quality, on-line river discharge forecasting, biological impact on waste metal disposal, and nitrogen cycles in bogs.

Detailed information on the Department's research activities is available in Department Headquarters.
NEW INITIATIVES

During this past year, the Department began work in a number of areas of long-term importance. The following are progress reports on two of these initiatives:

Center for Construction Research and Education. In order to establish an effective relationship with the construction industry, which could support and supplement research and educational interests of the Department of Civil Engineering, a Task Force on Construction Industry Research and Resource Development was appointed by Professor Joseph Sussman. This Task Force is chaired by Professor Fred Moavenzadeh. Also serving are Professors Irwig, Logcher, Marks, Sheffi, and Professors Charles Ladd and Charles Helliwell. The Task Force was charged with "preparing a plan for pursuing a viable Departmental program with the construction industry."

To quote from the Task Force report of March 1981: "The construction industry is currently challenged by several national and international socioeconomic concerns; the solutions of which require massive and increasingly complex construction programs. These include: the need to adjust to the world energy situation; the need to renew and rehabilitate the nation's declining industrial base and deteriorating infrastructure; and, the need to strengthen national defense. The construction industry's response to this rapidly emerging demand is being based on new ideas and innovations for improvements in traditional methods, technologies, and resources.

"The Task Force is of the opinion that the development of these new ideas and innovations can be enhanced and accelerated by aggregating various intellectual and financial resources available to the industry as a whole, and directing them toward achieving conceptual breakthroughs in understanding the industry's underlying technologies and processes. It is therefore recommended that the Department establish a Center for Construction Research and Education to serve as a mechanism for aggregation of both academic and industry resources.

"The proposed Center for Construction Research and Education is a challenging and worthy venture for the Department of Civil Engineering. It holds the opportunity for forming a meaningful partnership with a vitally important industry and providing mutual access to a largely untapped source of financial and intellectual resources. More importantly, it holds the potential for increasing both parties' contributions to solving issues of primary importance to the world today."

The Task Force is continuing to develop the themes and plans for the Center. We expect to move toward the establishment of a Departmental Center over the next academic year.

Laboratory Facilities. Substantial investment in laboratory facilities is required to bring our experimental activity in both teaching and research up to the level of our theoretical activities. While some progress has been made (e.g., in the structural lab and water quality teaching lab), much remains to be done across the Department (e.g., in the fluid dynamics area).

One area of particular emphasis this past year has been the planning for a major laboratory facility for experimentation in the areas of geotechnical engineering, resource extraction, and construction materials, as a co-venture by the Civil and Mechanical Engineering departments. The proposed laboratory will provide a joint experimental facility for teaching and research.

There is a common theme that runs through design, research, and teaching in these areas, namely the dominant importance of characterizing material and structural response. Theory and experimentation are based on many common principles, methodologies, and techniques. While a great deal of activity exists in these areas, it is currently focused on the theoretical side. Experimental work has been hampered by the lack of an effective experimental facility. In view of this handicap and the importance of what we have come to call the REMERGENCE area (for Resource Extraction, Materials and Energy, Reservoir, Geotechnical ENVironmental and Construction Engineering), a faculty working group from the Departments of Civil and Mechanical Engineering, under the leadership of the Heads of these departments, was established to consider alternatives. This group has become convinced of the intellectual and economic benefits of a combined effort, involving a pooling of space, equipment, and technical staff.

Over the next academic year, the two departments plan to continue the development of the joint Civil Engineering, Mechanical Engineering REMERGENCE Laboratory for experimental research and teaching.
The following faculty and staff members were promoted during this past year: Dr. Francois Morel was promoted to full Professor, Dr. Steve Lerman to tenured Associate Professor, Dr. Yosef Sheffi and Dr. David Ashley to Associate Professor. In addition, Carl Martland was promoted to Principal Research Associate, Trond Kaalstad to Senior Administrative Officer, Elizabeth Schumaker to Senior Lecturer, and Dr. E. Eric Adams, a lecturer in the Department, to Principal Research Engineer in the Energy Laboratory.

Dr. T.W. Lambe, Edmund K. Turner Professor of Civil Engineering, retired from the faculty after 32 years of distinguished service to the Department, the Civil Engineering profession, and the geotechnical community. A colloquium of the "Past, Present, and Future of Geotechnical Engineering" will be held at MIT in October 1981, in honor of Professor Lambe on the occasion of his retirement.

James Sloss, a senior lecturer in the Department since 1972, also retired.

Professor James E. Becker resigned from his faculty post to enter professional practice in the Boston area.

We expect that each of the above will remain involved in the teaching and research activities of the Department.

Two new faculty members joined the Department in February 1981. Dr. Wallace K. Melville became an Associate Professor in the Water Resources and Environmental Engineering Division, and Dr. Henry Irwig joined the Construction Engineering and Project Management group of the Constructed Facilities Division, also with the rank of Associate Professor.

Extensive searches for junior faculty were carried out, and four new Assistant Professors will join our faculty during the 1981-82 academic year. Drs. Victor Li, Shyam Sunder, and Amr Azzouz will join the Constructed Facilities Division, and Dr. Philip Gschwend will join the Water Resources and Environmental Engineering Division. Additional searches in each of the divisions of the Department continue.

After five years of distinguished service, Professor Frank E. Perkins stepped aside as Department Head to take on the role of Associate Provost. Professor Joseph Sussman became Head of the Department in August 1980.

Particularly notable among the honors achieved by our Department faculty are the following: Professor Carl Cornell was elected to the National Academy of Engineering. He joins Professors Robert Whitman, Donald Harleman, and Dr. Lambe, colleagues in the Department who were previously elected. Professor Harleman was invited to present the First Hunter Rouse Hydraulic Engineering Lecture in August 1980, a special honor for him and the Parson Laboratory, which he directs. Professor Whitman will give the Terzaghi Lecture in October 1981. It is among the most important and prestigious honors available in the geotechnical professional community.

Three members of the Department’s faculty were on sabbatical during the year. Professor Francois Morel spent the first semester in France writing and lecturing. Professor Moslen Baligh spent the year in Egypt, participating in research activities. Professor Paul Roberts was in residence at the University of California at Berkely, working on research and writing.

The quality of the junior faculty of the Department was recognized by the appointment of Dr. Michael Meyer as the Class of 1922 Career Development Assistant Professor (for two years beginning July 1981) and Dr. Harry Hemond as an Edgerton Career Development Assistant Professor (for two years beginning July 1981). Dr. Sallie Chisholm will continue as Doherty Associate Professor of Ocean Utilization for another year, and Dr. Rafael Bras will continue as the Gilbert Winslow Career Development Associate Professor for another year. As an indication of the esteem in which the junior faculty of the Department is held, almost 40 percent of the current junior faculty have held, or currently hold, career development chairs.

Professor Irvine published a text entitled "Cable Structures" in May 1980.

Professor Ladd was the recipient of the Department’s award for conspicuously effective teaching.
Antonio Sa da Costa, a recent Ph.D. student in the Department, received two awards for his thesis work, the American Water Work Association Academic Excellence Award, and the Lorenz E. Straub Award. His thesis supervisor was Professor John Wilson.

The Department’s faculty and staff continued its very active service to the profession through activities in a number of organizations, government agencies, professional societies, conferences, and editorial responsibilities. We cannot begin to mention all such activities. However, by way of illustration, we note that 17 members of the Department serve on committees of the American Society of Civil Engineers (ASCE), and that numerous other faculty and staff serve in positions of responsibility in organizations such as the American Concrete Institute, the Transportation Research Board, and the Project Management Institute. Notable among these activities are the following:

Professor M. Manheim - Member of the Executive Committee, Transportation Research Board
Professor P. Eagleson - President-elect of the Hydrology Section, American Geophysical Union
Dr. R. Martin - President, Clay Minerals Society
C. Martland - President, New England Chapter, Transportation Research Forum
Professor C. Ladd - Board of Directors, Boston Society of Civil Engineering, Section of the ASCE

The Department is active in the affairs of the National Science Foundation with Professor Robert Whitman serving on the Advisory Committee for Earthquake Hazards, Professor Donald Harleman serving on the Advisory Board for the Civil and Mechanical Engineering Division, and Professor Ann Fetter Friedlaender serving on the Economics Panel.

To highlight our professional activities, the following are the current editorial responsibilities undertaken by our faculty:

Professor R. Bras - Associate Editor, Water Resources Research
Professor R. de Neufville - Bibliographic Editor, Transportation Research
Professor A. Friedlaender - Board of Management, MIT Press
Professor H. Irvine - Organized new MIT Press Series in Structural Mechanics
Professor S. Lerman - Associate Editor, Regional Science and Urban Economics
Professor O. Madsen - Member, Editorial Board, Applied Ocean Research
Professor C. Mei - Member, Editorial Board, Annual Review of Fluid Mechanics
Professor F. Morel - Member, Editorial Board, International Journal of Coastal Engineering
Professor Y. Sheffi - Associate Editor, Environmental Science and Technology
Professor E. Vanmarcke - Associate Editor, Limnology and Oceanography

The Department was pleased to have the following as visiting faculty during the past year:

Professor Gedalih Shelaf (Technion University)
Professor Hugo Perez La Salvia (Catholic University, Venezuela)
Professor Moneer Tewfik (University of Petroleum and Minerals, Saudi Arabia)
Professor Petr Chylek (SUNY - Albany)
Professor Masaki Sawamoto (Tokyo Institute of Technology) - through March 1982

VISITING COMMITTEE

The Department Visiting Committee met on April 9 and 10 and discussed many of the issues described in this report. This meeting marked the end of Harold Muckley’s term as chairman. We wish to thank Mr. Muckley for his effective leadership of the Visiting Committee and for his service to the Department. He will continue to serve as a member of the committee. Also completing their terms as members of the committee on June 30, 1981, are C. Vincent Vappi, W. Kenneth Davis, Arthur Z. Gray, Thomas J. Lamphier, Julian C. Madison, and Major General Charles J. McGinnis (ret). We wish to thank all the above for their help and guidance over the years.
Effective July 1, 1981, our new chairman is Dr. Harl Aldrich, the president of the Alumni Association.

The Department welcomes Dr. Paula J. Stone as a new member of the committee effective July 1, 1980.

SEMINARS

The Department participated in a number of seminars both at MIT and elsewhere in the US and abroad this past year. Notably among those conducted on the MIT campus are the following:

Offshore Engineering Seminar Series -- The Department, in cooperation with the Department of Ocean Engineering and the Sea Grant Program, conducted a series of nine seminars in the spring semester in an effort to stimulate industry-university interaction. The speakers were highly qualified engineers from oil companies and consulting firms.

James A. Henderson Memorial Lecture -- On April 30, Dr. Edward E. David, Jr., President of Exxon Research and Engineering Company, presented the eighth annual James A. Henderson Memorial Lecture sponsored by the Department of Civil Engineering. Dr. David, an MIT alumnus and member of the MIT Corporation and Executive Committee of the Corporation, talked on "Synfuels Superprojects: New Challenges for Project Management." The lecture was attended by 400 people from throughout the Institute and from the Boston professional community.

The Rebuilding of America -- During the Independent Activities Period, the Department offered a series of nine seminars dealing with the need to rebuild the civil infrastructure of this country. Various lectures dealt with issues of technology, design, maintenance, economics of the nation's bridges, dams, highways, railroads, cities, and water supply systems. The series was very well attended by students, faculty, and staff from throughout the Institute.

JOSEPH M. SUSSMAN

Department of Electrical Engineering and Computer Science

Although this has been primarily a year of sustained effort on initiatives taken previously and reported last year, there are significant new developments worthy of note, three already clearly assured of completion, and others in embryonic stages.

Through the generosity of Drs. Harold E. Edgerton, Kenneth J. Germeshausen, and Herbert E. Grier, along with participation of the EG&G Corporation, the new EG&G Education Center will become a reality in the fall of 1982. The new building, comprising five stories and located between the present Buildings 36 and 38, will provide a much-needed major focus for Departmental educational, professional, and social activities. It will contain a 330-seat auditorium, featuring back-projection TV and other audiovisual facilities; a 150-person conference room with kitchen facilities, which can be divided into two smaller units when desired; four classrooms, each for 35 persons; and, on the top floor, major additional undergraduate educational laboratory space contiguous to that which already exists in Building 38.

A symbolic groundbreaking for the new building was held on June 4, 1981, and we hope to occupy the building in time for the celebration on October 2 and 3, 1982, of the Centennial birthday of Electrical Engineering at MIT. Plans for exciting events on this Centennial occasion are being carried forward under the direction of Professor Robert Fano. It is also hoped that at about the same time, research on the history of the Department, carried out during the past 15 years by Professor Karl Wildes, will bear fruit in a book tentatively entitled "A Century of Electrical Engineering at MIT," by Professor Wildes and Nilo Lindgren.
During the past year, we have put into place a new graduate-level educational program. Responsive primarily to perceived needs of local industry, the Master's Degree Program for Students in Industry features: classroom subjects taken on campus only; a full semester in residence on campus; and opportunity for the S.M. thesis to be carried out off campus in a manner analogous to that enjoyed by VI-A students, involving S.M. thesis supervision by a Departmental faculty member as well as a qualified off-campus professional. Admission to this program is exactly on the same basis as admission to the Department's regular graduate programs. Professor James L. Kirtley is directing this activity, which requires major interfacing with the companies whose employees participate in the program.

Less developed but no less significant than the foregoing undertakings are our efforts to revitalize interest in both scholarship and effective teaching among the faculty and graduate-student staff of the Department. A new textbook series covering both undergraduate and graduate "core" material, and employing innovative computer-aided document preparation methods, is in the active planning stages with potential authors and publishers. And we have reestablished in the Department the grade of Instructor (G) for those Teaching Assistants who have shown extraordinary performance in their teaching activities.

In similar early stages of development are plans for major new research thrusts into the fields of robotics and the hardware side of data and mixed-media communications, which we find at present are underrepresented areas in the Department compared to their expected importance in the future of the profession.

This is the last report the present Department administration will submit, inasmuch as Professor Gerald L. Wilson will become Dean of Engineering effective September 1, 1981. We wish to express our appreciation for the opportunity we have had to work with the remarkable people who really make this Department the outstanding organization that it is.

Undergraduate Program

Enrollment of undergraduates averaged 1,050 in 1980-81, an increase of about 75 from the previous year. Enrollment next year is expected to be approximately 1,130.

The third common core subject, 6.001 Structure and Interpretation of Computer Programs, was introduced this past year. The fourth and final subject in the core sequence, 6.004 Computation Structures, is being developed by Professors Stephen A. Ward and Robert H. Halstead and is expected to be offered in the academic year 1982-83.

The Department's undergraduate offerings in the semiconductor device physics area were modified to provide greater access to the increasing numbers of interested students. The availability of device-related research and laboratory experience for undergraduates is still limited by physical resources and the number of faculty.

The Undergraduate Educational Policy Committee approved the offering of several new elective courses: 6.201 Introduction to Dynamic Systems; 6.913 Public Policy Issues Involving Computers, Communications, and Information; 6.911 Contemporary Digital MOS Circuits; 6.912 Introduction to Decision Making with Uncertainty; and 6.142 Microprocessor-Controlled Energy Systems.

The Ernst A. Guillemin Prize for the outstanding undergraduate thesis in Electrical Engineering was awarded to Mohammed N. Islam of Endicott, NY. The Computer Systems Prize for the outstanding undergraduate thesis in Computer Systems was awarded to John A. Goree of Durham, NC.

A General Motors Scholarship was awarded to Robert C. Kidd of Warren, Ohio. An Eastman Kodak Scholarship was awarded to Donald G. Baltus of Tonawanda, NY.

Graduate Program

In September 1980, there were 554 graduate students enrolled in the Department. Of this number 170 were newly admitted students. About 20 percent of the total were foreign nationals. The Department supported 242 research assistants, 106 teaching assistants, and awarded 15 fellowships. In addition, there were 15 National Science Foundation Fellows and 20 Hertz Fellows. The remaining students had industrial or foreign government support or were using their own funds.
During 1980, the Department awarded the following graduate degrees: 153 Masters of Science, 26 Electrical Engineers, and 42 Doctors of Philosophy.

The Department received 1,401 applications for the 1981-82 year, the largest number we have had. The applicants were generally excellent and 285 were admitted, of whom we expect 189 to register for next fall. Four students were admitted for September 1981, to the new Master's Degree Program for Students in Industry. This program, deliberately targeted for five or less students this first year, is expected to expand over the next two or three years until it contains a total of 20 to 25 students.

Graduate students Daniel C. Brotsky, Jon N. Powell, and Andrew E. Yagle 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 John T. Wroclawski.

The Department of Electrical Engineering and Computer Science promoted Larry R. Carley and Kaigham J. Gabriel to Instructor-G.

VI-A Program

Student demand for the Program continued to grow, with 195 applicants topping last year's all-time record of 168. They represented 54 percent of the second-year students in Course VI, and about a three percent increase over a year ago. At the start of academic 1980-81, 16 percent of the total undergraduate and graduate population in the Department was enrolled in the VI-A Program, the highest in the Program's 64-year history.

Significant was this year's Departmental decision to place a ceiling on the size of VI-A in spite of the rapidly increasing enrollment in Course VI. This is the first time this has been done. By limiting the incoming classes in each of the next three years to about 85 students, rather than the recent average of about 100, the Program should level off at 250 students. The growth of VI-A over the past 10 years has already resulted in a size which significantly taxes the Department faculty's ability to handle the Program. Some 32 serve as VI-A faculty advisors to the companies, while others serve as thesis supervisors to students in the graduate phase of the Program. A moratorium on increasing the number of companies (or equivalent new divisions) has also been imposed, consistent with the enrollment limitation described above.

The only new company joining VI-A this year, therefore, was Tektronix, Inc. of Beaverton, OR, with which negotiations were begun some five years ago and finally culminated in a contract which started in June 1981.

For his "exemplary service to the Institute," which includes 12 years as Director of the VI-A Program, John A. Tucker was honored by the Institute with the presentation of a Gordon Y. Billard Award at its Award Convocation in March.

RESEARCH

Most research is performed in Departmental or interdepartmental laboratories. Information on their work appears in portions of this report dealing with the following laboratories: the Electric Power Systems Engineering Laboratory (EPSEL), the Research Laboratory of Electronics (RLE), the Laboratory for Computer Science (LCS), the Artificial Intelligence (AI) Laboratory, the Energy Laboratory, the Laboratory for Information and Decision Systems (LIDS), the Operations Research Center (ORC), and the Center for Materials Science and Engineering (CMSE).

The following research groups are otherwise unaffiliated: Continuum Electromechanics Laboratory, High Voltage Research Laboratory, and MIT Stroboscopic Light Laboratory. Highlights of this year's research from these groups is reported here.
Continuum Electromechanics Laboratory (J.R. Melcher)

By design, projects within this Laboratory have both basic and practical goals and a common theme of the interactions between electromagnetic fields and ponderable media.

Professor Alan J. Grodzinsky and his students have been studying and modeling the electromechanical and physicochemical properties of connective tissues. Articular cartilage in normal and diseased states is the focus of a major collaborative project. An important event in the development of osteoarthritis (OA) is the disruption and loss of electrically charged molecules from cartilage. Recent experiments on a surgically induced model of OA in rabbits (developed at Children's Hospital, Boston) have confirmed this loss. The accompanying decrease in the rabbit cartilage's mechanical stiffness during the first few weeks after surgery have correlated with changes in biochemical properties, which are characterized at Children's Hospital. These early changes in OA are difficult to study in humans, and are important in the understanding of the etiology of the disease. Dynamic mechanical and electromechanical measurements are now being used to further quantify the events during the early onset of OA in the rabbit model. Other major projects concern electric field-control of the permeability of charged membranes, and the physical characterization of electrosurgical coagulation. In the former project, experiments have shown that an electric field applied across a collagen membrane may alter intermolecular spacing and hence alter solute permeability.

Professor J.H. Lang, in collaboration with Professor D.H. Staelin, the Research Laboratory of Electronics, and their students, are combining elements of continuum electromechanics and distributed-parameter-system control theory in the development of low-mass high-precision electromagnetic reflectors for use in space. Here, electrostatic forces are used to shape the desired parabolic figure of a flexible-membrane reflector. The required control technology has been experimentally demonstrated and a five-foot reflector is currently under construction.

Professor James Melcher and his students continue to develop electrical approaches to solving problems of air pollution control. Novel electrostatic precipitation techniques are being developed for the control of automotive diesel exhaust. With application to this and also large-scale particulate control problems, a macroscopic theory for predicting the filtration performance of electrofluidized and electropacked beds has been developed. In work related to the development of magnetic precipitators for the protection of steam turbines and for the management of particles used for drag reduction in aerodynamic boundary layers, new theoretical approaches have been developed for predicting particle migration in the face of turbulent diffusion.

Stroboscopic Light Laboratory (H.E. Edgerton)

Progress has been made on the photography of plankton in the oceans. A previously constructed MIT camera has been redesigned and built by the Benthos Company, North Falmouth, MA for Dr. Peter Ortner (NOAA, Virginia Key, Miami) with cooperation from the MIT Strobe Lab. This camera has been tested at sea and a technical article ("An Insitu Plankton Camera") is being prepared for publication. It is believed that the results will give new information about plankton, and indirectly, to many related ocean problems.

A summer seminar on high-speed photography and videography was held June 8 to 12 and was directed by Charles Miller. Twenty students attended plus an equal number of staff and representatives from the field. This seminar seems to be finding a useful place in the education of scientists in experimental research with high-speed photography.

Designs are being considered for the application of television techniques to the study of underwater subjects. Methods of putting the equipment at the right place underwater are essential.

A penetration sonar of 6kHz (Massa) has been designed to operate from a nine-inch dry paper EPC Recorder. This recorder, when mounted on the bow of a small boat, makes it possible to obtain under-bottom sonic records in shallow water, even right up to the shore. The equipment is scheduled to be used at Halieis, Greece this summer where Professor Michael Jameson (Stanford University) is searching for under-bottom artifacts.

The penetration sonar is also to be used in Venice on a harbor survey with Dr. Antonia Stafanon. The new unit will supplement the use of conventional geology research instruments.
Faculty promotions this year included Arthur B. Baggeroer, Louis D. Braida, and Barbara H. Liskov to full Professor; and Dimitri A. Antoniadis, Christos H. Papadimitriou, Michael M. Salour, and Cardinal Warde to Associate Professor.

James R. Melcher has been appointed the first Julius A. Stratton Professor of Electrical Engineering. L. Rafael Reif was awarded the first Analog Devices Career Development Assistant Professorship of Electrical Engineering for two years, and Michael M. Salour was awarded an Esther and Harold E. Edgerton Associate Professorship for a similar period. Stanley R. Rich was appointed Gordon Adjunct Professor of Electrical Engineering, and William F. Schreiber was appointed Gordon Professor of Electrical Engineering, part time.

Joining our faculty this year were Dr. Thomas H. Lee, formerly Chief Technologist at the General Electric Company, appointed Professor of Electrical Engineering and awarded the Cecil H. Green Professorship of Electrical Engineering for the academic year; Dr. Charles E. Leiserson, who received his Ph.D. at Carnegie-Mellon University, now Assistant Professor of Computer Science and Engineering; Dr. Sosale Shankara Sastry, who received his Ph.D. from Stanford University, now Assistant Professor of Electrical Engineering; Dr. Henry I. Smith, formerly Adjunct Professor and Assistant Group Leader at Lincoln Laboratory, now Professor of Electrical Engineering; Dr. Markus Zahn, former Associate Professor of Electrical Engineering at the University of Florida, now Associate Professor of Electrical Engineering, Dr. Richard E. Zippel, previously a research associate in the Laboratory for Computer Science, now Assistant Professor of Computer Science and Engineering; and Dr. Victor Zue, formerly a research associate with the Research Laboratory of Electronics, now Assistant Professor of Electrical Engineering.

Dr. Michael Athans, Professor of Systems Science and Engineering, received the American Automatic Control Council's Education Award in recognition of his outstanding contributions and distinguished leadership in automatic control education. Dr. Fernando J. Corbató, Professor of Computer Science and Engineering, received the Harry Goode Memorial Award from the American Federation of Information Processing Society, in recognition of his contribution to the development of time-shared computer systems. Dr. Wilbur B. Davenport, Professor of Communications Science and Engineering, was awarded an Aerospace and Electronic Systems Society 1981 Pioneer Award for his development of spread-spectrum communications. The Polish People's Republic awarded the Golden Cross of the Order of Merit to Dr. Harry C. Gatos, Professor of Electronic Materials and Molecular Engineering, in recognition of his "contribution to the development of scientific cooperation between Poland and the United States." Dr. Hermann A. Haus, Elizhu Thomas Professor of Electrical Engineering, was nominated to the American Academy of Arts and Sciences. Dr. Erich P. Ippen, Professor of Electrical Engineering, was honored by the Optical Society of America with the R.W. Wood Prize for pioneering work in optical subpicosecond spectroscopy.

Dr. James H. McClellan, Associate Professor of Electrical Engineering, and Dr. Zue, received awards from the Graduate Student Council for outstanding teaching in a graduate subject.

The Department was happy to welcome two visiting faculty during the academic year. Visiting Professor Norman Abramson, on sabbatical from the University of Hawaii, taught a subject on satellite communications. Visiting Professor Yannis P. Tsividis, on sabbatical from Columbia University, taught a subject entitled Design of Analog MOS LSI, in fall 1980.

Department faculty who were away during the year include: Professor Athans, away on sabbatical during the spring of 1981 at Alphatech, Inc.; Professor Edward Fredkin, on leave of absence at the Three Rivers Corporation and the Robotics Institute at Carnegie-Mellon University; Professor Richard C. Larson, on leave as Visiting Professor at the Institute of Mathematical Statistics and Operations Research at the Technical University of Denmark; Professor Sanjoy K. Mitter, on sabbatical for the spring term, at the Institute of Mathematics in Florence, Italy; Associate Professor Vaughan R. Pratt, away at Stanford University; Professor Joseph Weizenbaum, completing a two-year leave of absence at the Institute for Mathematics and Information Processing (G.M.D.), in Bonn, Germany; and Associate Professor Alan S. Willsky, for the fall term 1980, as a Lecturer at the Laboratory for Signals and Systems, Superior College of Electricity, France.
Department of Materials Science and Engineering

Assistant Professor Irene Greif and Adjunct Professor G. David Forney resigned from the Department.

Professor John M. Wozencraft retired from the Department.

The Department was saddened by several deaths: Marcy Eager, Associate Professor, Emeritus, of Electrical Engineering, a long time administrator of the then Electrical Engineering Cooperative Course VI-A (now called the VI-A Program); William A. Martin, Associate Professor of Computer Science, a leading figure in the practical application of artificial intelligence; and George C. Newton, Professor of Electrical Engineering, widely respected for teaching and research in servomechanisms, radar, and digital systems.

GERALD L. WILSON

Department of Materials Science and Engineering

Last year the Acting Department Head, Professor Bernhardt J. Wuensch, reported that the rapid increase in the undergraduate and graduate populations had reached record levels in the postwar history of the Department. The increase in the number of students electing to study in the Department continued through last year, with 127 undergraduates and 208 graduate students registered. This unprecedented expansion in our activities placed further strains on our resources. It was necessary to add other sections to the undergraduate laboratories and to utilize every square inch of space that we could find in the Department. Our freshman subject, 3.091 Introduction to Solid State Chemistry, continued to be very popular.

The research activities also continued to expand. There are, of course, many reasons for the unprecedented interest in materials science and engineering at the present time. One important reason is that developments in materials -- particularly in materials processing -- are clearly of central importance in many of the technological developments required to produce solutions to the nation's energy problems and to increased productivity. In research, the emphasis has shifted in recent years from basic materials science to materials engineering and materials processing. It is important in these circumstances that we continue to have strong and viable programs in the basic sciences.

Undergraduate Program

The number of undergraduate students registered in the Department (127) represented a further increase over the record of 122 established in the previous year. The percentage of minorities remained about the same as in 1979-80. The percentages of undergraduates who are women reached the remarkable level of 42 percent, a higher percentage than in any other department in the School of Engineering.

Student interest in Course IIIB, the Department's Cooperative Work-Study Program, has continued to increase. There were 55 students, 46 percent of our undergraduate population, who participated in the program and were placed in 37 different companies, representing a broad cross-section of industry. During the past year some of the work which Professor Thomas B. King had done to launch the program so successfully was taken over by Joseph M. Dhosi. Professor King will continue to act as an advisor to the program. Interest among industrial companies continued at a very high level. There are many more companies wishing to have Coop students spend time with them than there are students available to fill these vacancies.

Enrollments in 3.091 were again well over 500 in 1980-81. Thus, a large proportion of freshmen at MIT continued to satisfy the Institute Chemistry Requirement by attending 3.091. The subject is taught and supervised by Professor August F. Witt in the fall term and Professor Robert M. Rose in the spring. Most of the recitation sections are conducted by faculty members with the assistance of graduate teaching assistants. The popularity of the Department's required subject, 3.081 Materials Laboratory, had been manifested by an enrollment of 115 in the spring of 1980. In hopes
of spreading the load placed on teaching and facilities, the course was offered in both terms of 1980–81. The result was an enrollment of 45 in the fall term with no significant decrease in the spring term (112).

Undergraduate involvement in faculty research continues to expand. During the academic year, 91 Undergraduate Research Opportunity Program projects were performed, 31 for academic credit and 60 for compensation. An additional 24 projects were done in the summer of 1980.

Graduate Program

In 1979–80 there were 172 graduate students in the Department. This number rose in 1980–81 to 208; 60 percent of these students were supported by research assistantships and 21 held fellowships, many of them provided by industry. More than 62 percent of the graduate students were US citizens and the remainder were international students. Thirty-five of the students (17 percent) were women.

Fifty graduate degrees were awarded, of which 15 were doctorates. Eight master's degrees and one of the doctorates were received by women.

The John Wulff Award for outstanding service by a teaching assistant was presented to Leszek Pawlowicz, and the Falih N. Darmara Award for academic achievement, research, and extracurricular activity was presented jointly to Daniel P. Button, Patricia T. Foley, and Marc H. LaBranche.

Nearly a decade ago, we planned graduate academic programs in five interrelated activities. Three programs deal with the integrated science and engineering of a specific class of materials: Ceramics, Polymers, and Metallurgy. The two remaining fields concentrate on either the science of materials or the engineering of materials and, thus, are concerned with generalizations applicable to all materials. In the intervening years we have developed and taught the necessary subjects, recruited appropriate faculty, and attracted the necessary research support for these five programs. Now the plan is virtually complete and the programs are all vigorous and, in most cases, even more successful than we had hoped at the beginning. With the appointment of a professor specializing in the physics of polymers and a joint appointment in polymers with the Department of Chemical Engineering, our recruitment program will be completed. Of course, since the development of our undergraduate and graduate programs has been accompanied by a remarkable increase in the number of students, our recruitment of faculty has also been much influenced by the need to provide teaching for the large student population.

RESEARCH

In previous years, I have attempted to summarize the major research activities underway in the Department. This has now become a task which is impossible within the space available in this report. Departmentally administered research expenditures for 1980–81 were at $6.1 million. However, it is important to emphasize that there has been a remarkable increase in research within the Department which is concerned with the processing of materials. This is a development which has taken place nationally and is being strongly encouraged by various agencies in Washington and by industry. Much of the credit for the developments at MIT must be given to Professor Merton C. Flemings, Director of the Center for Materials Processing, who has been instrumental in organizing and encouraging this remarkable growth. Special mention should be made of the work of Professor Nicholas J. Grant who has been the pioneer in developing techniques for processing new alloys and other materials with unusually fine grain size—materials which have come to be known as microcrystalline materials. This technique has revolutionized the whole field of alloy development and promises to be among the most important developments in materials in the next two decades. In all of this activity and in related developments of the excellent group in Ceramic Processing, directed by Professor H. Kent Bowen, we are fortunate in having received the collaboration of many industries. Indeed, these close working relationships with industrial laboratories, and the financial support which industry has provided, are among the most encouraging aspects of our total research activities.
In addition, many of our faculty have received support through the Center for Materials Science and Engineering, which continues to provide experimental facilities and a focus for work in materials science. Other faculty members have continued their traditional associations with the work of the Energy Laboratory and other laboratories on campus, such as the National Magnet Laboratory. Much, but by no means all, of the research carried out by members of the Department and their students is referred to in the reports of the Center for Materials Science and Engineering, the Center for Materials Processing, the Energy Laboratory, and other research units at MIT.

FACULTY

In the past year Professors Roland M. Cannon, Thomas W. Eagar, and Gregory J. Yurek were promoted from assistant to associate professor. Professors Joel P. Clark and Harry L. Tuller received tenure, and Professors Ronald M. Latanision and John B. Vander Sande were promoted from associate to full professor. Dr. Gary Wnek joined the Department as an assistant professor in our expanding activities in polymers, and Dr. Terry A. Ring, who specializes in mineral engineering, was named assistant professor with a joint appointment with the Mining and Minerals Resources Research Institute at MIT. We are fortunate to have Professor Linn W. Hobbs, currently at Case Western Reserve University, joining us in the fall as an associate professor (untenured). Professor Hobbs is a specialist in the applications of modern electron microscopy to the study of ceramics. Thus, he will help strengthen the work being done by Professor Vander Sande and his associates in the Electron Microscopy facility of the Center for Materials Science and Engineering; and at the same time, he will reinforce the outstanding work in ceramics which has been done in the Department for many years.

Members of the faculty continue to receive many honors and awards. Among these are the following:

Professor Robert W. Balluffi was named the R.F. Mehl Medalist by the Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) in March of 1981 and he will present the 1982 Institute of Metals Lecture.

Professor Michael B. Bever was named Fellow of the American Association for the Advancement of Science.

Professor H. Kent Bowen received the F.H. Norton Award as the Distinguished Ceramist in New England for 1980-81.

Professor Robert L. Coble was named Trustee of the Basic Division, American Ceramics Society.

Professor Nicholas J. Grant was named Fellow of the American Institute of Mining and Metallurgical Engineering. He also received the H. Krumb Award of AIME as the annual lecturer of 1979-80.

Professor Donald R. Uhlmann received the George W. Morey Award of the American Ceramics Society for 1981. He was named a Guggenheim Fellow for 1981-82.

Professor Bernard J. Wuensch was awarded the Distinguished Exchange Scientist Fellowship of the Humboldt Foundation by the Max-Planck Institut fur Festkorperforschung and will spend several months in 1981 at Stuttgart.

During parts of last year, Professors John F. Elliott, Thomas B. King, and Walter S. Owen were on sabbatical. Professor Wuensch served as Acting Department Head during the summer and fall terms of 1980.

The Department hosts a large number of visiting professors and scientists from many countries. Last year we received 43 such visitors -- too large a number to mention any individual by name.
Department of Mechanical Engineering

The field of mechanical engineering is a profession broadly concerned with energy, motion and materials, and the design, production, and management of systems to meet the needs of society. In virtually all of the most challenging problems we face in the 1980s and beyond, whether they be secure and economical supply and efficient utilization of energy, defense, health care and human rehabilitation, protection and enhancement of the environment, industrial productivity, or safe and efficient transportation, mechanical engineers have a vital role to play. While the practice of mechanical engineering is changing rapidly owing to the explosive advances in information processing and real-time computation and control technology, the growing ability to synthesize new materials and composites, the expanding role of the life sciences and human factors, and the increasing need to deal with uncertainty and risk, the field has never been more exciting nor more promising than it is today.

Industry demand for mechanical engineering graduates at all degree levels remains very strong with premium salaries offered compared with most alternative engineering and scientific fields. The past year saw intense competition for Ph.D. graduates interested in engineering education as mechanical engineering departments throughout the country struggled to cope with continued growth in undergraduate enrollments. While the number of doctoral graduates from the Department has remained approximately constant over the past several years, the fraction of foreign student graduates has grown significantly reaching about 67 percent last year. In the spring only one of the students accepted into the doctoral program was a US citizen. This disturbing trend, which exists throughout the US, reflects the intense competition by industry for graduates at the S.B. and S.M. levels, and increased interest in graduate study in such fields as management, law, and medicine, rather than engineering.

Two new studies* were published in 1980 rating graduate and professional programs and undergraduate programs in American and international universities. The Department is pleased to note that both its undergraduate and graduate programs are again ranked first in the nation. Earlier studies by other rating groups published in 1976, 1975, 1970, and 1966 also ranked the Department as number one.

In spite of continuing heavy workloads and financial stringency, the Department proceeded with several important initiatives. An interdepartmental workshop held in September explored the prospects and potential for new educational programs in manufacturing at the master's level, and concluded that an appropriate first step would be the development of departmental options under existing approved degree offerings. As a follow-up, the Department began revising several existing and developing two new graduate subjects to form a coherent sequence in manufacturing.

On the research side, a joint proposal between the Department and the Department of Civil Engineering for a new laboratory in resource extraction, geotechnical, and construction engineering (REMERGENCE Laboratory) was completed. Planning for a coordinated educational and research program in energy-efficient buildings led to a formal proposal to establish a Center for Energy Efficient Buildings as a joint program between the Departments of Mechanical Engineering and Architecture. Several research programs in this area have already been funded in both departments by outside agencies.

New research programs in robotics and manufacturing productivity were initiated, and a new Computer-Aided Design Laboratory was formally established.

Owing to Federal budget cuts planned for fiscal year 1982 and 1983, considerable uncertainty exists in the Department regarding support for research and graduate students over the next few years. Because the Department has a very diverse research program with many government and industry sponsors, the impact is likely to be less than for the Institute as a whole. However,

*Gorman Reports, National Educational Standards, Inc., Los Angeles, CA
it seems clear that certain areas such as environmental research will suffer seriously, and faculty
who have had continuing programs will be required to shift to other fields of research. Early
admissions data suggest that the entering graduate student body this fall will be smaller than in
recent years because of reductions in financial aid. While it is much too early to assess the impact
of the changing Federal priorities and levels of support, it is reasonable to expect a serious reduc-
tion of US advanced degree graduates in mechanical engineering within one or two years. If so,
this will be unfortunate in times when more, not less, advanced degree graduates in mechanical
engineering are needed.

PROGRAMS OF INSTRUCTION

The primary objectives of the Department's instructional programs are to educate mechanical engi-
neers for leadership roles in professional practice and engineering education and to provide a
broad and flexible background for entering related fields such as medicine, law, management,
and public policy. The programs emphasize a broad background in the engineering sciences
combined with a strong design orientation and practical laboratory experience which connects
theory and analysis with the physical world. At both the undergraduate and graduate levels,
involvement of students with faculty research at the forefront of engineering practice -- through
special projects, the Undergraduate Research Opportunities Program (UROP), and theses -- is a
hallmark of the Department's educational process.

The curricula, as well as individual subjects are reviewed and evaluated by the Academic Policy
Committee, established in 1979, to ensure quality, relevance, and coherence. This Committee also
has responsibility for identifying and stimulating new curriculum developments and for recommending
to the faculty policies regarding all aspects of the academic programs. The members are Professors
Joseph L. Smith, Jr., chairman, Ali S. Argon, and J. Karl Hedrick. This year the Committee
reviewed and approved nine new subjects to be offered beginning in 1981-82, initiated a review
of the graduate school policies, and continued planning for a major revision of the undergraduate
curriculum which the Committee believes is necessary to meet the major changes which are expected
in the profession by the end of this decade and beyond.

The Schedules Officer, Professor Ernest Rabinowicz, works effectively with the Division Heads
and the Department Head to implement the Department's three-year planning cycle for teaching
assignments and curriculum development. This process has proved highly effective since its
initiation in optimizing limited faculty and financial resources to make possible new subject develop-
ment and the writing of several important new textbooks.

The quality of the subjects and of instruction as perceived by students is evaluated systematically
twice each semester through the course and instructor evaluations conducted by the student
honorary society Pi Tau Sigma. The end-of-term course evaluations are available to all Depart-
ment students and instructors, while the instructor evaluations go only to the instructor and the
Department Head. The feedback provided by this process is an important factor in achieving the
high quality of teaching which the Department enjoys, and is useful toward recognizing out-
standing teachers.

Undergraduate Programs

Undergraduate enrollment remained stable at approximately 400 students, as it has for the past
two years, following growth by about a factor of three during the 1970s. Sophomore enrollment
in 1980 was 119 compared with 118 for 1979. It is encouraging that 12.6 percent of this year's
sophomores are blacks (including five women) and 13.4 percent are women. This is the first
year that the number of blacks has approached the number of women. In the total undergraduate
population, the fall 1980 data show 58 women (14.5 percent) and 55 minorities (13.8 percent) of
whom 18 are women. Thirty of the minority students (including nine women) are blacks, repre-
senting 7.5 percent of all undergraduates.

The Department offers the S.B. in Mechanical Engineering (Course II), which is accredited by the
Accreditation Board on Engineering and Technology of the American Association of Engineering
Societies, and the S.B. without specification (Course II-A), which is non-accredited. Course II-B,
the Engineering Internship Program leads to the S.B. and S.M. in Mechanical Engineering with
industrial experience as an integral part of the program.
Course II-A, administered by Professor Thomas B. Sheridan, allows students to design interdisciplinary programs which combine a strong base in mechanical engineering fundamentals with subjects relevant to professional fields such as biomedical engineering, management, computers and computation, energy production, medicine, or energy policy. Approximately 11 percent of all undergraduates are in Course II-A.

In 1980-81, the Department awarded 120 S.B. degrees (100 in Mechanical Engineering and 20 without specification). Among the graduates were 12 women (one black) and three blacks (one woman).

The undergraduate program is managed through the Undergraduate Office by the Undergraduate Officer, Professor David Gordon Wilson and his assistant, Peggy Garlick. The Office coordinates activities between the Department, the Registrar's and Schedules Offices, and the Committee on Academic Performance. It supports the Pi Tau Sigma course and instructor evaluations, lists job opportunities, oversees UROP projects and undergraduate thesis procedures, supplies program information, and is a source of sympathetic advice and counsel for undergraduates.

Under the direction of Departmental Instructor, Josie Stein, the Undergraduate Enrollment Committee organized a presentation of the Department's programs for freshmen at the Academic Midway in September and also at the Mechanical Engineering Department Open House for Freshmen in April.

The Undergraduate Committee, chaired by Professor David C. Gossard, includes both students and faculty and serves as a policy forum for all matters affecting undergraduate life. Among the issues raised this year for departmental consideration were: developments needed in the educational program to prepare students to cope with the increasing diversity, complexity, and disciplinary breadth of the mechanical engineering profession; the need for new elective subjects in microprocessor technology and biomedical engineering; the need for a more suitable student lounge; and issues related to grading and the heavy student workload in laboratory subjects.

A major revision of the core subject, 2.30 Mechanical Behavior of Solids (12 units), planned last year was implemented for the first time this year, under the direction of Professor Robert O. Ritchie. The subject has been replaced by a two-term sequence, 2.31 and 2.32 Mechanical Behavior of Materials I and II, with an increase of total units from 12 to 18. A coordinated laboratory spans both semesters. These new subjects, which have been well received by the students, are intended to provide a strong understanding of materials behavior and a basis for materials selection in design. Development of these subjects and the laboratory will continue next year under the leadership of Professors Argon and Frank A. McClintock with the objective of writing a new textbook for the subjects.

In the design area, Professor Carl R. Peterson developed and will introduce next year 2.72 Elements of Mechanical Design (12 units) which is an elective subject recommended for students interested in mechanical design. When taken between the two required design subjects, 2.70 Introduction to Design and 2.73 Design Projects, this subject will provide additional depth and experience in the innovative design process and in the selection and integration of machine elements, power and control components, and materials.

Professor Peterson, together with Lecturer Robert G. Lundquist, and Professors Herbert H. Einstein of Civil Engineering, and John F. Elliott of Materials Science and Engineering, developed a new elective subject, 2.742J Introduction to Mining and Mineral Technology (9 units) which will provide a broad, yet basic, introduction to the mining and minerals industries with emphasis on state-of-the-art technology.

Professor Neville Hogan developed a new subject, 2.04 Probability and Statistics in Mechanical Engineering (12 units), to be offered in the fall of 1981. This subject, which may eventually be integrated into the required core program, includes such topics as random variables and processes, spectral analysis, sampling, parameter estimation, confidence intervals, hypothesis testing, and correlation functions.

The core undergraduate subject, 2.40 Thermodynamics, was changed, on an experimental basis, from the individual section mode to a lecture-recitation format. The advantages of this format are reduction of faculty lecture preparation time and standardization of material presentation, while the disadvantages included reduction of direct faculty-student interaction which enhances development of engineering insight.
The undergraduate laboratories constitute a critical element of the undergraduate educational experience in mechanical engineering. Included in the required core are 2.671 Measurement and Instrumentation and 2.672 Project Laboratory, and the laboratories associated with 2.86 Manufacturing Processes and 2.31, 2.32 Mechanical Behavior of Materials I, II. In addition, many undergraduates take the restricted elective 2.14 Control System Principles which has a coordinated laboratory.

The bulk of funds needed to refurbish and re-equip the laboratory for 2.31 and 2.32 have been raised, and refurbishment is in progress. In addition to state-of-the-art testing equipment and transducers, this laboratory will feature computer-controlled real-time data acquisition, analysis and graphical as well as numerical display.

Professors Henry M. Paynter, David E. Hardt, and Paul K. Houpt acquired new space for and initiated the re-equipping of the laboratory for 2.14 Control System Principles. Each term between 60 and 90 students perform four control system laboratory projects, utilizing an interactive digital terminal as well as bench-top analog computers to synthesize controllers for real physical systems and investigate the performance, stability, and robustness of the systems when under control.

The Student Chapter of the American Society of Mechanical Engineers (ASME) increased in size from 104 to 176 under the leadership of its officers: Barry Cheskin, president; Kurt Armbruster, vice president; Eva Shimaoka, treasurer; and Charles Frankel, secretary. Professor Bruce M. Kramer served as faculty advisor. A series of speakers from industry met with the Chapter and two industrial plant trips were arranged during IAP. The members compiled a student resumé book which was printed by the MIT Industrial Liaison Office and distributed to member companies. The Chapter strengthened ties to the ASME national organization by participating in student activities at the winter annual meeting in Chicago.

Black ME is an organization of black students which helps to recruit minorities into the Department and provides a supportive environment and career guidance for minority mechanical engineering students. Ten new members were added this year, bringing the total membership to 45. The faculty advisor is Professor Stephen H. Crandall, and the officers this year were: Nathan Graham, president; William Watkins, vice president; LeVonne Collins, secretary; George Lyons, treasurer; and Akwete Akoto, lounge officer.

Pi Tau Sigma, the mechanical engineering honorary society, continued its tradition of fostering student-faculty relations and serving the Department through its course and instructor evaluation program. Among the social events sponsored were a fall cookout and a spring banquet at MIT's Endicott House. The Society helps to finance its own activities through sales of mechanical engineering T-shirts with creative logos. Professor Warren P. Seering was elected as faculty advisor beginning this year, replacing Professor Ernest G. Cravalho who had served for several years. The following students began serving in the spring and will continue through 1981: George J. Lombardo, president; Mark L. Walker, vice president; Robert M. Collins, treasurer; and John A. LaPlante, secretary.

Many undergraduates in the Department were recognized this year for academic excellence, engineering expertise, and community service. Among the most notable are the following:

Rebecca M. Henderson was one of three MIT women to receive an Association of MIT Alumnae Award for academic excellence. She also was elected to Phi Beta Kappa and Tau Beta Pi, the honorary engineering society.

Senior J. Randolph Andrews, for the fourth consecutive year, won the coveted First Prize in the Deflorez Award competition which recognizes "outstanding ingenuity and creative judgment," for his design and construction of a four-degree-of freedom manipulator and controller for research in impedance control of robots.

Barry N. Cheskin was the 1981 School of Engineering recipient of the Honeywell Award for Outstanding Achievement in Engineering which was presented by the Company at the Department awards luncheon in May.
At the Institute Awards Convocation, Senior Anitta L. Bliss received the Karl Taylor Compton Prize for her contributions to McCormick Hall activities and to the MIT Chapter of the Society of Women Engineers.

Kerin S. Yura was named a Kodak Scholar for 1981-82, and Frederick S. Leonard and Lisa A. Washington were selected as General Motors Scholars.

Engineering Internship Program

The School of Engineering Internship Program (EIP), for which Professor Igor Paul is the Department representative, has successfully completed its third summer of operation, and student placement at participating companies for the fourth summer (1981) has been arranged. The Program has grown from a total of 33 students placed at 12 companies in 1978 to 108 placed in 32 companies in 1980. The Department of Mechanical Engineering has participated strongly in the EIP, accounting for 33 percent of the students in 1978, and approximately 50 percent in the summers of 1980 and 1981.

Last fall, the first mechanical engineering students were admitted to the graduate school and are pursuing the graduate portion of the EIP, with an off-campus graduate thesis advised jointly by a Department faculty member and a company supervisor. Of 11 students entering the program, five are continuing on to the master's program under the EIP; the others have either decided to graduate at the bachelor's level or are pursuing a regular on-campus master's program.

At its March 1981 meeting, the Mechanical Engineering Department Visiting Committee expressed enthusiastic support for the EIP and strongly recommended that the Program be encouraged and expanded in light of the serious industrial needs for graduate mechanical engineers and in the face of the increasing costs of engineering education.

Graduate Programs

Enrollment in the graduate school increased by about 13.5 percent from 334 in 1979-80 to 379 last year. Applications from both foreign and US students remained at about the same level as in 1979-80, approximately 25 percent higher than in 1978-79 and the previous years.

The Department awarded 120 Master's, four Mechanical Engineer, and 19 doctoral degrees in 1980-81, 14 to women and one to a black. Overall, about 31 percent of the Department's graduate students are foreign, but at the doctoral level an increasingly large fraction are foreign. In 1980-81, 50 percent of the doctorates were awarded to foreign nationals, and in the doctoral qualifying examinations last May, only one of the successful candidates was a US citizen. This trend, which is even more pronounced in other graduate schools in this country, is a very serious matter for US industry, universities, and government to recognize and take actions to redress. Among the reasons for this trend are the intense financial competition from US industry for mechanical engineers at the S.B. and S.M. levels, the increasing cost of graduate education coupled with dwindling sources of support, the drop in salaries for doctoral graduates relative to those offered to graduates with lesser degrees, and growing student interest in industrial practice as opposed to research or teaching.

In the graduate school as a whole, the number of students supported by the Department through research and teaching assistantships rose from 202 in 1979-80 to 226 this past year, representing 62 percent of all graduate students. Overall, the number of graduate students receiving support from the Department or through fellowships dropped from about 90 percent in 1979-80 to 72 percent in 1980-81.

The pending changes in Federal policy including severe reductions in research support, possible elimination of the Guaranteed Student Loan Program, and plans to phase out the National Science Foundation (and other agency) fellowships beginning in 1981-82 do not augur well for the future of graduate engineering education nor for the future technical leadership potential of the United States.
The graduate program was directed by Professor Warren M. Rohsenow and his assistant, Sandramarie Williams through the Graduate Office. The Graduate Committee, chaired by Professor Rohsenow, provides a forum for discussion of graduate school policy and assists in the admissions process and in administering the degree requirements.

During the past year, six new graduate subjects were developed and will be introduced during 1981-82.

In the spring of 1982, Professor Seering will offer 2.732 Advanced Design Projects, which will be a continuation of his highly successful subject 2.731 Advanced Engineering Design. Lectures and class discussions will cover such topics as product safety and liability, entrepreneurship, product marketing, patents, and methods of redesign. Students will, from components built for them by participating industrial clients, assemble and "debug" the devices which they designed for the clients in course 2.731 the previous semester. These two courses will be supported financially by the participating companies who will provide the design problems and receive the resulting hardware solutions.

Subject 2.745J Interdisciplinary Design of Wave-Power Conversion Devices, a joint course with the Department of Ocean Engineering, was developed and offered on a special project basis last spring by Professors Wilson and Paynter, together with Professors A. Douglas Carmichael and J. Nickalos Newman of Ocean Engineering.

In the area of biomedical engineering, Professor Padmakar P. Lele developed 2.762J Non-Ionizing Radiation in Biomedical Sciences, which covers the physics, biological effects, hazards, and safety levels of laser, microwave, ultraviolet, and ultrasonic radiation as applied to medical diagnosis, treatment, and biomedical research.

As part of the development of new coherent graduate programs in manufacturing, the following three new subjects will be introduced next year. Professors Rabinowicz and Nam P. Suh will offer 2.800 Tribology which is a comprehensive treatment of both classical and new theories of friction, wear, and lubrication of metals and non-metals with practical applications to materials processing and wear prevention. Professor Hardt has developed 2.830 Control for Manufacturing Automation which provides background for the application of computer-based control system techniques to the automation of batch manufacturing, with emphasis on metal cutting, metal forming, and robotics. Finally, Lecturer Michael B. Packer will offer 2.840 Productivity Analysis and Improvement in the spring of 1982. This course, which was tested on a special project basis this past year, covers the field of organization-level productivity analysis and improvement methodology in both manufacturing and service organizations.

In addition to these new subject developments, several faculty members substantially completed graduate-level textbooks which will be published in the near future: Professor Ronald F. Probstein, Synthetic Fuel Production; Professor John B. Heywood, Internal Combustion Engines; Professor Tau-Yi Toong, Combustion; and Professor Wilson, Turbomachinery Design.

Jae R. Youn and his coauthor Professor Suh received the 1981 Best Paper Award of the Society of Plastics Engineers for their paper, "Tribological Characteristics of Surface Treated Polymers."

Dana R. Yoerger received the 1980-81 Department Student Service Award "for exceptional and dedicated service as Departmental Instructor." During his tenure as instructor in 1979-80, Mr. Yoerger created the software necessary to compose the Department's annual report using the Joint Computer Facility so that copy can be sent directly to the typesetter's computerized system by telephone.

**RESEARCH**

**Volume, Composition, Scope, and Trends**

The total volume of sponsored research for 1980-81 is estimated at $12.2 million, about 10 percent higher than the previous year, and representing approximately $230,000 of support per faculty member. During the past several years an increasing fraction of faculty research has been
managed through the interdisciplinary centers and laboratories. At present, about 42 percent is managed directly by the Department and 58 percent through such units as the Laboratory for Manufacturing and Productivity (LMP), the Energy Laboratory, the Center for Materials Science and Engineering, the Electric Power Systems Laboratory, and the Harvard–MIT Health Sciences and Technology (HST) Program.

Research support derives from a diverse number of Federal and industrial sources, with some research groups (e.g., automotive and manufacturing) now receiving more than 50 percent of their support from industry.

Unrestricted funds which enable the Department to enter new fields of research which are not yet recognized as important by Federal funding agencies or by industry, to enhance the career development of junior faculty, and to acquire critical research equipment remain scarce. However, several corporations, individual alumni, and foundations have continued to make modest annual unrestricted gifts to the Department. These funds have been used carefully and have paid off richly in fostering junior faculty professional growth and in initiating new programs which have subsequently developed into major sponsored activities.

While a wide range of applications-oriented research is carried on, most projects can be grouped in four major areas of emphasis: manufacturing and processing, energy and environment, biomedical engineering, and systems including transportation. The percentages of faculty working in these areas are approximately 40, 47, 20, and 16 percent, respectively, with a number of faculty involved in two or more of the areas. During the past several years, as the Department has grown, the percentage of faculty involvement in manufacturing and processing has increased from about 25 percent to 40 percent while involvement in the other areas has remained static or declined slightly. The area of energy and environment continues to be the largest area of research in terms of faculty involvement, although a significant trend toward increasing research in energy conversion and conservation and decreasing environmental research is evident. The Department’s program in biomedical research, which spans all three of the disciplinary areas and is well connected to other MIT departments, to Harvard Medical School, and to area hospitals and institutions, is one of the strongest and broadest in any US mechanical engineering department.

Although some shifts have occurred in Federal funding priorities, financial support for fundamental research in the mechanical engineering disciplines remains difficult to secure. As a result, much of the Department’s basic research is funded as part of applications-oriented programs. Among the active areas of fundamental research during the past year were: computational mechanics and the fatigue, deformation, and fracture of metals, polymers, composites and porous/geological materials (Professors Argon, Ritchie, Klaus Jürgen Bathe, Michael P. Cleary, Frank A. McClintock, David M. Parks and James H. Williams, Jr.); friction and wear or tribology (Professors Kramer, Rabinowicz, and Sub); theory and measurement of fluid flows, quantum thermodynamics, ignition and combustion, combustion instability, plasmas, and biosystem kinetics (Professors Heywood, Toong, George E. Abouseif, Wai K. Cheng, C. Forbes Dewey, Jr., Elias P. Gyftopoulos, James C. Keck, Stephen B. Pope, Alician V. Quinlan, and William C. Unkel); dynamics of fluid flow in collapsible tubes (Professors Roger D. Kamm and Ascher H. Shapiro); heat transfer in insulation, fluidized beds and two-phase fluids (Dr. Leon R. Glicksman and Professors Rohsenow, Peter Griffith, Borivoje B. Mikić, Michael B. O’Callaghan, and Maher A. El-Masri); random vibration and structural acoustics (Professors Crandall and Richard H. Lyon); and nonlinear dynamics and control (Professors Hardt, Hedrick, Houpt, and Paynter).

New Programs and Notable Accomplishments

In the area of Biomedical Engineering, the new Eric P. and Evelyn E. Newman Laboratory for Human Mechanics and Rehabilitation completed its first year of operation under the leadership of Professor Robert W. Mann, Whitaker Professor of Biomedical Engineering. With its newly renovated space, experimental and fabrication facilities, and novel systems for instrumentation and real-time computer control and data analysis for human prosthesis and rehabilitation aids research and development, the Laboratory now represents perhaps the premier activity in the world concerned with applying technology to aid the physically handicapped. Associated with the Laboratory is the MIT Sensory Aids Evaluation and Development Center of which Professor Derek Rowell is director. Among the current activities of the Center is research and development by Professors Rowell and Mann and Principal Research Engineer Dr. Michael J. Rosen on the Universal Communicator (UNICOM) which permits disabled people who are unable to speak and
have severe motor handicaps to communicate. This year 14 units were in field use by cerebral palsy, stroke and muscular dystrophy victims, and by quadriplegics in both home and school environments. A wide range of research in mobility and rehabilitation is ongoing in the Laboratory and the Center including, for example, computer-controlled lower limb prostheses (Professor Woodie C. Flowers), neurophysiologically based control strategies for prostheses and orthoses (Professor Hogan), and technology for control of spasticity and for return of lower limb function through afferent nerve stimulation in spinal cord injuries (Dr. Rosen).

Exciting results were obtained this past year by Professor Lele in the application of hyperthermia, through use of focused ultrasound, to the treatment of cancer. Following remarkable success with dogs having malignant, inoperable tumors, Dr. Lele treated 45 terminal human patients who had superficial head and neck cancers refractory to conventional therapy. More than 50 percent regression was obtained in the product of the tumor major cross-diameters together with relief of pain, and several patients were in fact saved. Based on this success, a major program in collaboration with several local hospitals, the MIT Clinical Research Center, and the Harvard–MIT Division of Health Sciences and Technology (HST) has been initially aimed at extending the basic technology to deeper and larger tumors using computer-based measurement and control techniques. Hyperthermia is based on the observed fact that healthy cells can survive temperatures slightly above those which will kill cancerous cells; thus the key to successful treatment is the maintenance of uniform, carefully controlled elevated temperature within the tumor.

In a somewhat related effort, Professors Paynter and Rowell continued work on an interactive, computer-based radiation therapy planning system using color graphics and integration of data from a variety of diagnostic sources.

Professors Kamm and Shapiro continued research into biomedical fluid mechanics of the cardiovascular, respiratory, and ocular systems with clinical application to the external treatment of deep venous thrombosis, respiratory disease, and glaucoma, respectively.

In his research on artificial skin, Professor Ioannis V. Yannas and his collaborator Dr. John F. Burke of the Shriners Burns Institute obtained dramatic success in clinical evaluation of "Stage 1" artificial skin on 10 human patients with deep and extensive burns. Three of the patients who otherwise might have died survived as a result of the treatment. The artificial skin consists of an inner layer composed of collagen fibers in a matrix of mucopolysaccharide and an outer silicone layer. After periods as long as 45 days, it was possible to replace the outer layer with thin epidermal autografts (the patients' own skin from elsewhere on the body) with little scarring.

In Manufacturing and Processing, the Laboratory for Manufacturing and Productivity (LMP), formed in 1977 and now a School of Engineering Laboratory, continued to grow and expand its scope. At present, 75 graduate students and 25 faculty from six departments are associated with the LMP and a fiscal year 1982 funding level of $2.3 million is projected with 60 percent industrial support. The Department continues strong coupling with the Laboratory; during the past three years, three new junior faculty have joined the Laboratory and three more will be added next year. The Manufacturing Resources Program initiated last year by Assistant Director Dr. Michael B. Packer has developed rapidly with several active research projects in productivity measurement and analysis under way. A new initiative in robotics was launched under the leadership of Professors Hogan and Hardt in cooperation with the Artificial Intelligence Laboratory. Work on real-time adaptive, microprocessor-based control of sheet metal forming by Professors David C. Gossard and Hardt led to a successful controller which will be introduced commercially by the sponsoring company in its line of servo-controlled press-brake machines.

Other manufacturing-related research initiated recently includes automation and real-time control of welding (Professors Hardt, Paynter, Unkel, Koichi Masubuchi of Ocean Engineering, and Thomas W. Eager of Materials Science and Engineering); nondestructive evaluation and moisture detection (Professors Suh and Williams); machine dynamics (Professors Lyon and Seering); and innovative fiber processing (Professor Stanley Backer). Research under the direction of Professor Lewis Erwin is addressing the problem of molding the fragile ablative materials used on the reusable Space Shuttle fuel tank. The concepts developed have the potential for $500,000 in cost savings per tank. Professor Hardt initiated new research in the automation of fiber-reinforced plastic part manufacture and the control of manufacturing processes (such as glass molding and forming) which have large measurement delays.
The area of Energy and Environment involves about half of all Department faculty and accounts for a major fraction of all sponsored research. During the past year important new developments were under way in energy conservation in buildings and systems, resource extraction and mining, and automotive performance.

Under the leadership of Senior Research Scientist Glicksman, progress was made toward the development of a coherent research program, jointly with the Department of Architecture and the Energy Laboratory, emphasizing the development of new conservation and design techniques for energy-efficient buildings and the transfer of the results into design practice. At the end of the past year, 30 graduate students and 10 faculty were carrying out research funded at more than $700,000 per year on such specific topics as solar lighting, absorption cooling and earth sheltered buildings (Professor Thomas P. Bligh); moisture transfer in porous media and insulation (Professor El-Masri and Dr. Glicksman); aging of foam insulation (Dr. Glicksman); convective heat transfer from building surfaces (Professor Mikid); and architecture-based work on daylighting, solar cooling, energy-conscious design, thermal energy storage, and energy-effective architectural finishing materials.

Jointly with the Department of Civil Engineering, a detailed proposal was developed for the formation of a new joint facility for experimental research in Resource Extraction, Materials and Energy, Reservoir, Geotechnical, Environmental, and Construction Engineering; the REMERGENCE Laboratory. When fully developed, this laboratory facility is expected to support an externally funded research program at a level of more than $1 million per year in the areas of underground fracturing for in-situ extraction of minerals (oil, shale, coal, gas, and metals), mining machinery and systems, underground transportation tunnels, ground/structure interaction, and new construction materials.

In a study completed in December 1980, a School of Engineering Ad Hoc Committee on Research in Automotive Technology recommended the establishment of a coherent Automotive Performance Program, to include research relating to the operating characteristics, efficiency, and performance of propulsion systems and vehicles. Initiative for developing this program has been accepted by the Department's Sloan Automotive Laboratory under the leadership of Professor Heywood, director, and Dr. Joe M. Rife, executive director. In cooperation with the Industrial Liaison Program, an industrial consortium of automotive and petroleum companies is being formed to support the Program and ensure coupling of research results into industrial practice. Among the technical areas to be included when the Program is fully implemented are engine combustion, emissions formation and control, tribology, engine diagnostics and feedback control, engine-fuel interactions, aerodynamics, vehicle and drive train dynamics, and noise and vibration.

This past year a new Departmental Laboratory for Mining Systems Development was established by Professor Peterson. Supported by an industry consortium and Federal funds, this new laboratory emphasizes remote control of underground coal mining systems to enhance worker health and safety while improving overall productivity.

Several programs related to nuclear power were under way during the past year. Professors Griffith, Mikid, Rohsenow, Ain A. Sonin, and Peter W. Huber studied heat transfer, circulation modes, instability modes, fluid-structure interactions, and natural circulation in nuclear reactor systems.

Dr. Glicksman, in collaboration with Professor Adel Sarofim of Chemical Engineering continued research on fluidized beds.

Ongoing research on superconducting generators under the direction of Professor Smith continued as a joint effort between the Cryogenic Engineering Laboratory and the MIT Electric Power Systems Engineering Laboratory. The 10-megawatt generator is currently scheduled for service testing on the MIT power systems in 1984.

Dr. Yukikazu Iwasa, senior lecturer and member of the Francis Bitter National Magnet Laboratory continued work on superconducting magnets for magnetohydrodynamics and fusion reactors.

Professor James A. Fay initiated research on the use of small-scale (0.01 to 10 MW) tidal power in New England and continued work on scale effects in dense vapor dispersion in LNG spills.

Research on desalination and water systems was continued in the Fluid Mechanics Laboratory under Professor Probstein.
Developments in the area of Systems including Transportation this year included further expansion of the highly successful Vehicle Dynamics Laboratory and Man-Machine Laboratory and formal establishment of a new Computer-Aided Design Laboratory within the Department.

Under the leadership of Professors Hedrick, Houpt, and David N. Wormley, the Vehicle Dynamics Laboratory expanded its work in rail systems with emphasis on rail safety, development of design methodology for passenger vehicle rail trucks, and track measurement and standards. The new program in automotive vehicle diagnostics and control was also expanded in collaboration with the Sloan Automotive Laboratory.

Professor Sheridan directed a broad program in man-machine systems research which has grown significantly during the past three years. A new direct-digitally controlled manipulator was constructed this past year, and a cooperative program with the Naval Ocean Systems Center in San Diego was under way which will result in a prototype free-swimming underwater robot. Other projects involve development of improved human/computer interfaces for supervisory control, failure detection, and emergency procedures for complex systems such as nuclear power plants.

Building on several years of previous work, Professor Gossard established a new Computer-Aided Design Laboratory which focuses on advancing the state-of-the-art in computer-aided design and graphics both for professional practice and as an educational aid. Research in education is aimed at new concepts for using the computer and graphic displays in mechanical engineering education. Under support of the Westinghouse Foundation several prototype teaching programs have been developed and class tested including: VISUAL, a drafting tutorial; BEAM, for teaching simple beam behavior; VIBE, which displays transient and steady state responses of second-order systems; and TRANSIENT, which displays step response of linear systems for courses in system dynamics. Research on symbolic dimensioning was continued and expanded with the objective of developing more flexible methods for definition and modification of parts in computer-aided design. During the past year, extension of previous two-dimensional work into a three-dimensional program known as DIMENSION III was initiated. Industrial support for this research expanded by more than a factor of two this year, and new state-of-the-art equipment was provided by the Computervision Corporation.

Other notable activities in the area included Professor Wilson's research on man-powered vehicles and Professor Wormley's research on pure fluid (fluidic) hydraulic servo-control valves which have demonstrated performance comparable to that of conventional moving-part electrohydraulic valves.

**FACULTY AND STAFF**

**Size and Composition**

Over the past three years, owing to modest increases in the Department's general budget and School of Engineering efforts to attract industrial support for junior faculty, the Department has been fortunate to add several outstanding assistant and associate professors. In 1980-81 the Department had 53 regular faculty members, 26 professors, 12 associate professors, and 15 assistant professors, with a ratio of tenured to untenured faculty equal to 0.58. In addition, the staff includes two senior research scientists, one of whom is also an adjunct professor, as well as a number of part-time lecturers who contribute to the academic program.

The distribution of women and minorities on the faculty remained unchanged, despite continued extensive search for qualified candidates. The regular and adjunct faculty includes three Asian Americans, one black, and two women. Of the seven administrative and exempt staff, five are women and of 32 support staff all are women and one is black. There are three blacks among 16 hourly staff and of three technical exempt employees, one is Asian American.
Notable Accomplishments and Awards

Frederick H. Anderson, technical instructor, and Ralph Whittemore, project technician, were honored both by the Department and the Institute. They were presented James N. Murphy Awards for dedicated service to community life at the Institute, and also won the Department's James Holt Staff Service Award for "dedication, empathy and skill in education of generations of students."

Professor Elias P. Gyftopoulos was elected to the National Academy of Engineering in recognition of his important contributions in nuclear reactor dynamics, thermodynamics, and industrial energy conservation.

Professor Ernest G. Cravalho was elected to the Institute of Medicine, recognizing his contributions to cryobiology and education in medical engineering and medical physics.

Professor Stephen H. Crandall was elected a foreign member of the Polish Society for Theoretical and Applied Mechanics, and also received a Centennial Medallion of the American Society of Mechanical Engineers.

Professor Ronald F. Probstein was one of nine MIT faculty elected as Fellows of the American Association for the Advancement of Science.

The Society of Manufacturing Engineers named Professor Lewis Erwin as Outstanding Young Manufacturing Engineer for 1980, recognizing his contributions to the field of manufacturing.

For the second consecutive year, Professor Robert W. Mann served as Sigma Xi national lecturer.

Professor David M. Parks was appointed as Esther and Harold E. Edgerton Associate Professor of Mechanical Engineering, a career development chair.

The Process Industry's Division of the American Society of Mechanical Engineers awarded a Centennial Medallion to Professor Joseph L. Smith, Jr. based on his contributions to cryogenic engineering.

Professor Nam P. Suh served as chief technical advisor to the United Nations Industrial Development Organization Program in Korea.

New Faculty

Dr. Wai K. Cheng, who received his Sc.D. from the Department of Aeronautics and Astronautics in 1979 and joined industry, has returned to MIT as an Assistant Professor of Mechanical Engineering. Professor Cheng is associated with the Fluid and Thermal Sciences Division of the Department and is a member of the Sloan Automotive Laboratory. His current research involves application of modern diagnostic instrumentation and computer-based modeling to complex unsteady combustion processes, with application to diesel engines.

Visiting Faculty

The Department was host to the unusually large number of nine visiting faculty.

Visiting Assistant Professor Behrouz Abedian, who holds a position as Assistant Professor of Mechanical Engineering at Tufts University, collaborated with Professor Ain Sonin on research in electric charging phenomena in liquid hydrocarbon flows.

Professor S. Standford Manson, on sabbatical from Case Western Reserve University, held a joint appointment from March through December 1980 in this Department and in the Departments of Aeronautics and Astronautics, and Materials Science and Engineering. During his visit Professor Manson contributed to a joint seminar subject, Advances in Fracture Research.

Visiting Assistant Professor Takuji Murao was on sabbatical from his post as Assistant Professor of Technology at Ehime University in Japan and during his visit he worked with Professor David N. Wormley in the Systems and Design Division.
Dr. James L. Park, Chairman of the Physics Department at Washington State University, held a visiting professorship in this Department and in the Department of Nuclear Engineering. He worked with Professors James C. Keck and Elias P. Gyftopoulos, and Senior Lecturer George N. Hatsopoulos in developing future directions for research in thermodynamics.

Dr. Edward Shwedyk, Associate Professor of Electrical Engineering at the University of Manitoba, Canada, spent the spring semester as a visiting associate professor working with Professor Mann and his colleagues in the area of myoelectric signal processing and with Dr. John R. Tole of HST in the field of EEG recording in infants.

Visiting Associate Professor Stefanie E. Stanzl spent her sabbatical from the Institute of Solid State Physics of the University of Vienna collaborating with Professor Argon in studies of cavitation in creeping alloys and the mechanics of macro-crack growth in such alloys.

Visiting Professor Elmar K. Tschegg, on leave from the Technical University of Vienna, worked with Professor Ritchie on life estimation for large turbine shafts and rotors subjected to complex stress histories.

Visiting Associate Professor Akira Watanabe was on leave from his position as Associate Professor in the Department of Medical Engineering, Institute of Medical Electronics, University of Tokyo. He worked with Professor Mann and colleagues on research in motor control of human extremities and physiological tremor.

Dr. Sheldon Weinbaum, who holds the Kayser Chair at the City University of New York, was a visiting professor, part-time, working with Professor C. Forbes Dewey, Jr., on fluid shear stress effects on arterial walls.

Resignations

The resignations of Assistant Professor Michael G. O'Callaghan and Class of 1922 Associate Professor Robert O. Ritchie were accepted with regret. Professor O'Callaghan resigned in January to join Dynatech Corporation, Cambridge, MA, and Professor Ritchie has accepted a faculty position at the University of California at Berkeley, effective September 1981.

ACADEMIC PROGRAM

At a time when many nuclear engineering departments are having difficulty meeting their enrollment goals, the Department has been able to maintain its graduate enrollment goal of between 150 and 160 students. In this graduate population we have seen an increase in the number of students choosing the fusion area. However, the undergraduates choosing nuclear engineering during this year dropped to 10 students, as compared to 20 last year. The total undergraduate enrollment is currently 40 students, well below our goal of 70 to 80.
Although the number of well-qualified applicants exceeded the number of openings, our limited financial aid, together with strong competition from other schools, has reduced the number of domestic students who have accepted admission. This has led to an increase in the fraction of admitted students who come from foreign countries to about 40 percent. We have strengthened our recruiting efforts with the aid of the student chapter of the American Nuclear Society in an effort to improve domestic acceptances.

The Department awarded 62 advanced degrees including 20 Doctorates, eight Nuclear Engineers, and 34 Masters of Science during the academic year 1980-81.

During the past year several changes in the academic program have been possible as a result of new faculty. Professor I. Wei Chen joined the staff as an assistant professor in January 1980. This and the probable addition of another assistant professor in nuclear materials during 1981 have permitted the development of three new subjects in nuclear materials which will replace the two currently offered. These new subjects will permit both an introductory subject for nonmaterial specialists, plus a strengthened program for those pursuing a career in the materials area. In the spring of 1981 Professor Richard Lester offered a new subject on radioactive waste management technology. This is the first subject on nuclear waste management to be taught at the Institute and is offered at a time when waste management issues are of growing interest in the United States and overseas.

The Engineering Internship Program, which offers undergraduates the opportunity to have on-the-job experience as part of their overall education, has been successful since it was initiated in the summer of 1978. A total of 10 students -- one graduate, three juniors, and six seniors -- are now in the program. Companies which have placed students from our Department are Brookhaven National Laboratory, Commonwealth Edison, EG&G Idaho, Stone & Webster Engineering Corporation, and Yankee Atomic Electric Company.

During the summer of 1980 the Department offered a Special Summer Session program on Nuclear Power Reactor Safety, directed by Professors Norman C. Rasmussen and Neil E. Todreas. This two-week program was attended by 180 people representing all segments of the nuclear industry and nine foreign countries. The Summer Session program "Man-Machine Interfacing in Nuclear Power and Industrial Process Control" was offered again in June 1981 jointly with the Department of Mechanical Engineering by Professors David Lanning and Thomas Sheridan. The program was very well attended; approximately 100 people participated.

In recognition of the need for news media personnel to acquire a deeper understanding of nuclear power-related issues, a special seminar, "Nuclear Power: Challenge for Journalists," was offered in October 1980. The seminar was directed by Professor Lester and was staffed primarily by Nuclear Engineering faculty. It was offered under the auspices of the Seminar Office of the Center for Advanced Engineering Studies. The goal of the seminar was to offer an intensive short course on nuclear technology and policy issues so as to increase the capacity of journalists to analyze, interpret, and seek advice on such issues when reporting nuclear power stories in the future. The Program was carefully designed to avoid staff advocacy of one policy position or another. The seminar, which was self-supporting, attracted approximately 35 participants from news organizations throughout the country.

Student Activities

The MIT student chapter of the American Nuclear Society hosted the Eastern Regional Student Conference on March 26-29, 1981. The Regional Student Conference gives undergraduate and graduate students an opportunity to professionally develop their technical skills by exchanging research results and communicating their findings through the presentation of papers. Over 150 students from the nuclear engineering departments of more than 14 colleges and universities from the Eastern United States and Canada participated in the Conference. A total of 16 awards was presented, eight of which were given to MIT nuclear engineering students. J. Andrew Combs (physics), Paul Gierszewski (fusion technology), Micahel Manahan (materials), David Petti (reactor safety), Martin Plys (neutronics), and Heidi Wyle (isotopes and radiation) won first prize for the best paper in their respective sessions. Martin Plys also won the prize for best paper in the power division, and Ms. Wyle won the prize for best paper at the Conference.
A number of members of the student chapter of the American Nuclear Society have been active in speaking to local groups on nuclear issues. This year the Department gave special awards to Messrs. Plys, Manahan, and Steven Piet for outstanding contributions in this area.

RESEARCH

The Department conducts research in the areas of applied radiation physics, energy and energy policy, reactor engineering (chemical engineering and fuel cycles, materials and structures, reliability and thermal hydraulics), reactor physics (experimental and theoretical), and plasma fusion (experimental and theoretical). During the fiscal year ending June 30, 1980, Department faculty supervised a research volume of $2,241,325, including research funded through the Department of Nuclear Engineering, as well as the MIT Energy Laboratory; the Harvard/MIT Division of Health Sciences and Technology; the Nuclear Reactor Laboratory; the Plasma Fusion Center; and the Research Laboratory of Electronics. The fiscal year 1980 research volume in the Department was $1,021,286.

During the year approximately 53 percent of the graduate student body was supported through research assistantships. An additional 12 percent were supported through Department teaching assistantships. Other financial aid is available to graduate students in Nuclear Engineering in the form of MIT-endowed grants and fellowships, namely the Sherman R. Knapp Fellowship (Northeast Utilities), the Theos J. Thompson Memorial Fellowship, the Institute of Nuclear Power Operations Fellowships, and the College Work-Study Program.

Research in the area of fusion technology and plasma physics continues strong. Professor Lawrence Lidsky continued his work on Torasotron-Stellarator Plasma Confinement systems with particular emphasis on particle and energy transport in their complicated geometries. In conjunction with Dr. Peter A. Politzer (now a member of the Plasma Fusion Center) and Dr. R.E. Potok, he demonstrated that such devices perform considerably better than had been expected. These results, reported at conferences in Munich and Kyoto, have had considerable impact on the international fusion program. Professor Thomas Dupree continues his work in plasma turbulence. Professor Jeffrey Friedberg has been working in the area of plasma stability using MHD theory; while Professor Kim Molvig's work in the area of TOKAMAK theory where his research on energy confinement is receiving considerable attention. Professor Mujid Kazimi continues his studies of fusion reactor safety.

In the area of reactor physics, Professor Allan Henry has continued his work on numerical modeling of the behavior of light-water moderated reactors. This research is sponsored by the Electric Power Research Institute (EPRI). Professor Michael Driscoll has continued his work on the neutronic design of advanced fast breeder reactor cores. The Department continues its broad activities in the area of thermal hydraulics and fluid flow. Professors Todreas, Lanning, and Kazimi, and Professors Michael Golay and John Meyer have contributed individually and jointly to studies of sodium boiling behavior in Liquid Metal Fast Breeder Reactors (LMFBR), Pressurized Water Reactor (PWR) single phase and steam generator modeling, two-phase flow in light water reactors, cooling tower fluid flow, and thermal problems in fusion devices. This last effort on divertor design of TOKAMAK fusion machines is an excellent example of how the broad engineering experiences gained from fission technology have many direct applications to the engineering design of fusion machines.

Professor Driscoll and Dr. Frederick Best are conducting research for the Department of Energy (DOE) on the extraction of uranium from seawater. As part of this effort, an international conference was held at MIT in December 1980, involving some 45 participants from six national programs in this area.

Departmental research activity in the area of nuclear materials continues to grow. Professor Meyer has investigated structural problems in nuclear fuel cladding. Professors Otto Harling and Kenneth Russell have continued two major programs in nuclear materials. One of these uses the MIT Research Reactor to investigate the influence of plasma bombardment on the mechanical performance of fusion reactor first walls. The other area is a continuing effort to develop improved nuclear structural alloys for the critical fusion reactor first-wall application. Professor Chen has studied the embrittlement problems in ferritic stainless steels due to intense irradiation which may be expected in fusion and fission applications. He also has initiated research of nonmetallic nuclear materials for fusion insulator and radioactive waste forms.
Professors Sow-Hsin Chen and Sidney Yip lead the Department's efforts in the area of applied radiation physics. Professor Chen has been awarded a NATO collaboration grant for assisting the Molecular Optics Group in the Physics Department of the University of Bordeaux, France. Professor Yip continues to carry out theoretical studies on the dynamics of dense fluids. In the area of nuclear medicine Professor Gordon Brownell continues his developments in the area of computer tomography for the diagnosis of disease. In this work, his laboratory at the Massachusetts General Hospital developed a tomographic positron camera that offers considerable promise as a diagnostic procedure. Professor Alan Nelson, who joined us this year with a joint appointment with the Harvard-MIT Division of Health Sciences and Technology, is developing a research program in the area of the effects of radiation on tissue. Professor Lanning, working closely with Professor Sheridan and the Draper Laboratory staff, is active in the problems of the man-machine interface in a nuclear power plant control room. Professor Lester has developed a sponsored research project in the area of radioactive waste disposal with Professor John Deutch of the Chemistry Department. Professors Rasmussen and Carolyn Heising-Goodman continue their work in the area of reliability analysis of nuclear power plants supported by the utility industry and government. Professor Elias Gyftopoulos continues his work in thermodynamics and energy conservation.

FACULTY

Professor Alan Nelson was appointed Assistant Professor of Nuclear Engineering. The appointment is joint with the Harvard-MIT Division of Health Sciences and Technology. His activities will be in the biomedical area.

Professor Carolyn Heising-Goodman was appointed Assistant Professor of Nuclear Engineering in the area of reactor safety and reliability.

Professor Peter Politzer resigned to take a position on the research staff of the Plasma Fusion Center.

The Department was happy to welcome the following visiting faculty during the academic year: Professor James Park, chairman of the physics department at Washington State University, was appointed a Visiting Professor of Nuclear Engineering and Mechanical Engineering for the period September 1980 to May 1981. Professor Park worked with Professor Gyftopoulos on new directions in thermodynamics in mechanical engineering. Visiting Professor Noel Pope, professor and head of the mathematics department at the Royal Military College in Canada, spent his sabbatical in the Department working with Professor Yip on the kinetic theory of liquids. Visiting Professor Bal Raj Sehgal was on leave from the Electric Power Research Institute and worked in the area of thermal hydraulics with Professor Todreas.

Professor David Rose spent three months as senior research fellow at the Resource Systems Institute of the East-West Center, Honolulu.

Professor Michael Golay returned to the Department from a sabbatical at Electricité de France.

The Department is pleased to report that Professor Kim Molvig was promoted to Associate Professor of Nuclear Engineering. He spent the spring term on leave at the Institute for Fusion Studies at the University of Texas at Austin and will return to the Department in the fall of 1981.

Nuclear Engineering faculty members continue to be active outside the Department in both MIT activities and in a wide variety of activities outside of MIT for professional societies, government, and industry.

Professor Rose continues this year as the US representative to the Asia-Pacific Energy Studies Consultative Group, which has included senior representatives from about 20 countries in that area, plus OPEC and several foundations. Professor Rose is a member of the program committee of the International Energy Symposium series, and activity preparatory for and related to the 1982 International Energy Exposition in Knoxville, TN. Professor Sow-Hsin Chen was invited as a Visiting Professor of Physics to the University of Guelph in Canada for the month of January 1981. During his visit he gave a series of four lectures on recent results in biophysical applications of neutron and light scattering.
Professor Driscoll has completed his term of service as the School of Engineering representative to the Institute's Committee on Educational Policy, and that committee's representative to the Committee on the Humanities, Arts, and Social Sciences. He continues to serve as faculty chairman of the MIT Undergraduate Seminar Program. He also continues to serve on the MIT Reactor Safeguards Committee. Professor Golay continued as chairman of the American Nuclear Society Environmental Sciences Division. In June of 1980 he presented a seminar at the Centre des Etudes Nucléaires at l'Energie Atomique in Grenoble, France. Professor Gyftopoulos continues as an advisor to the National Energy Council of Greece. Professor Kazimi serves as chairman of the Nuclear Heat Transfer Committee of the American Institute of Chemical Engineering, and a director of the American Nuclear Society (ANS) Northeast Section. In March of 1981 he participated in an International Atomic Energy Agency Workshop on Fusion Reactor Safety in Vienna, Austria. He serves on the review committee of the Department of Energy Fellowship for Magnetic Fusion Energy Technology. He is president of the Association of Arab-American University Graduates.

Professor Lidsky was instrumental in founding and is now editor-in-chief of the Journal of Fusion Energy, published by Plenum Press. The first issue of this quarterly publication appeared in January 1981. Professor Todreas serves as chairman of the Technical Working Group on Thermal Hydraulics for the ANS. He also is on the editorial board of the thermal design area of the Journal of Nuclear Engineering and Design. Professor Harling continues to serve as director of the interdepartmental Nuclear Reactor Laboratory. Professor Lanning continued as UROP coordinator for the Department and served as chairman of the search committee for a new Department Head.

Professor Heising-Goodman is vice chairman (chairman-elect) of the Northeastern Section of the ANS. She also serves on the national program committee of the ANS Reactor Safety Division. She is consultant to the joint NRC-ANS standards committee on probabilistic risk assessment. She is a member of the technical writing group of the ANS/IEEE Probabilistic Risk Assessment Standards. Professor Meyer serves as vice chairman of the Mathematics and Computation Division of the ANS. Professor Rasmussen was appointed to the safety advisory board, Three Mile Island Unit-2. He continues to serve as chair of the MIT Reactor Safeguards Committee. He serves as co-chairman of the IG/Idaho National Engineering Laboratory Scientific Review Committee at that laboratory. He was appointed a member of the Atomic Industrial Forum and a member of the National Committee on Radiation Protection.

Honors and Awards

Several of the Department faculty were recognized with honors during the past year. Professor Yip received the outstanding teacher award of the student chapter of ANS. Professor Todreas was elected a Fellow of the American Nuclear Society. Professor Rasmussen was elected a Fellow of the American Academy of Arts and Sciences. He also received the Theos J. Thompson Award from the Nuclear Reactor Safety Division of the American Nuclear Society.

This will be my last report as Head of the Department of Nuclear Engineering, for after six years I have chosen to step down and return to full-time teaching and research. The job has brought with it many rewarding moments; and, unfortunately, many tedious ones as well. The MIT system as it is now structured depends very much on getting our best and brightest people to accept the position of Department Head. If we are going to be able to do this in the future, it is important that the administration continue to vigorously strive to remove as much of the tedium as possible.

I wish Professor Neil Todreas every success as he takes over as the new Department Head. I know that he will do an outstanding job.

NORMAN C. RASMUSSEN
Department of Ocean Engineering

Ocean industries in the United States and abroad continue to offer challenging career opportunities to graduates of the Department. Most find employment in industries connected with commodity transportation, naval ship construction, or offshore petroleum. Also, a growing number of the Department's graduates find career opportunities in government service relating to the management and use of the oceans.

Ocean transportation of commodities continues to be a very important function served by the Department. A sizeable number of our students study ship-related technology and the management of shipping systems. Ocean transportation continues to command a large fraction of the US and world economy, and this fraction is growing as a result of the increasing interdependence of nations. Inland US shipping is also bound to grow in relative importance, given this nation's strength in the production of grain and the mining of coal, each of which requires efficient means of bulk transportation.

The Department is increasingly convinced that its program in ocean transportation can and should expand, with especial emphasis on those areas integrating economics and operations research with technology and management. At present, plans are being laid to develop an Institute-wide program in ocean transportation with a strong contribution expected from this Department.

Recent policy shifts by the Federal government point toward a strong US Navy, both in terms of number of ships and quality of technology. As such, the Department looks forward to further growth and strength in its program related to naval construction and naval technology. This affects not only the US Navy officer program (Course XIIIA), but also those students who opt for a civilian career with design agents or naval facilities supporting this new thrust.

As friendly observers of the technical components of the US Navy, we are keenly aware of the opportunity to serve the Navy through relevant education. If anything, needs for engineering personnel serving the US Navy are relatively greater than needs in either ships or equipment. In the past decade a potentially serious erosion of engineering strength has taken place which, in our view, needs to be stopped and indeed reversed.

The offshore oil industry continues to be an active employer of graduates of the Department. At present, we fall far short of meeting all requests by this sector of the industrial economy for our graduates. Here we are limited by the number of qualified students coming to the Department, so that we have increased our efforts to make better known the opportunities available in this field. Research related to the offshore industry, supported in part by the US Geological Survey and in part by industry directly, has increased dramatically this past year; this coupled with a revised and expanded curriculum in offshore engineering has promise of a larger group of graduates for this field.

Wallace Academic Prize and Wallace Lecture Program

The Robert Bruce Wallace Academic Prize is endowed by Albert H. and Marion W. Chatfield in memory of Mrs. Chatfield's father, Robert Bruce Wallace, Class of 1898, an alumnus of the Department and former president of the American Shipbuilding Company. The Prize is unusual in that it is awarded to a student for demonstration of outstanding potential for success in ocean engineering. It is not based solely on a student's grades and is independent of the student's financial need.

The first recipient of the Wallace Academic Prize, awarded for 1980-81, is James N. Hancock, Class of 1981 and the second recipient for 1981-82, is Peter Stein, Class of 1982. They were selected by a faculty committee from a large number of excellent candidates. The amount of the award approximates tuition and living expenses for one academic year.
The Robert Bruce Wallace Lecture Program is also made possible through the generosity of Mr. and Mrs. Chatfield. It normally consists of one or a series of lectures given annually by an eminent scholar or practitioner on a topic of importance in ocean engineering. The purpose of the program is to bring advanced ideas in ocean engineering and related fields to the attention of students and faculty of the Department, the MIT community, and the public.

Professor Torgeir Moan of the Norwegian Institute of Technology was selected as the first Wallace Lecturer. He was the engineering expert on the Norwegian royal commission which investigated the Alexander Keilland accident (the oil rig that collapsed into the North Sea in March 1980). On 28 April 1981, he delivered a major lecture at MIT on the engineering aspects of the accident. It attracted wide interest among offshore oil engineers (here and from other institutions), and students. As part of the lecture program he spent one week with students and faculty discussing various aspects of offshore structure design, structural fatigue, safety analysis, and operational aspects of the offshore oil industry in the North Sea.

The Cochrane Research Fund

Established this year as a tribute to Admiral Edward L. Cochrane, previously Vice President for Research, Dean of Engineering, and Head of the Department, the Cochrane Research Fund provides special grants to Department faculty for research equipment, computer analyses, or partial support of research students. The first such grants are to be awarded in 1981-82.

FACULTY

Arthur B. Baggeroer was promoted from associate to full professor and Robert J. Van Houten from assistant to associate professor. These promotions take effect July 1, 1981.

Professor Judith T. Kildow and J. Kim Vandiver were awarded permanent academic tenure effective July 1, 1981.

Captain John Sweeney has announced his retirement from the US Navy and his resignation as professor in the Department. Professor Francis Noblesse has resigned to accept a research position with the David Taylor Naval Ship Research and Development Center.

Professor Ernst G. Frankel spent a sabbatical year at the University of Singapore teaching and researching port planning. He also toured China for the World Bank and studied maritime policy and economics with the Federal Maritime Commission. Professor Justin E. Kerwin spent a sabbatical term preparing class notes and visiting the KMW Marine Hydrodynamics Laboratory in Sweden to observe their research and practice on propellers. Professor Ronald W. Yeung spent a sabbatical term at the Institute für Schiffbau Forschung in Hamburg, Germany studying ship-wave problems.

Visiting Faculty and Staff

Dr. Odd M. Faltinsen visited from the Norwegian Institute of Technology. An authority on the interaction of waves with structures, he pursued joint research with Professor Michael Triantafyllou and taught an advanced graduate subject on surface wave forces.

Yingzhon Liu visited from Shanghai Jiao Tong University. He has authored numerous papers on hydrodynamics. Xinsen Lu, also of Jiao Tong University, studied the interaction of structures and fluids during his visit.

Dr. Theodore A. Loukakis, Professor of Ship Theory at the National Technical University of Athens, offered seminars on propellers, seakeeping, hydrostatics, and instrumentation. He also assisted in the development of an experimental program for the testing of marine risers.

Dr. Kiyohide Terai (Kawasaki Heavy Industries and Visiting Lecturer at the University of Tokyo, Nagoya University, and Tokoku University) and Akihiko Imakita (Research Engineer with Mitsui Engineering and Shipbuilding Company) conducted welding research with Professor Koichi Masubuchi.
School of Engineering

Dr. Tomasz Wierzbicki, Professor of Mechanics at the Polish Academy of Sciences, worked with Professor Joao de Oliveira on a US-Polish research program, "Structural Aspects of Vehicle Crashworthiness."

Dr. Taketoshi Yamada, Associate Professor of Transportation Engineering at Tokyo University of Mercantile Marine worked with Professors Harilaos Psaraftis and Henry Marcus analyzing and simulating efficient ship and port systems.

Activities and Awards

Professor Martin Abkowitz was selected as chairman of the Design Review Committee on Mine Countermeasure Systems of the Naval Coastal System Center.

Professor Baggeroer serves as treasurer and associate editor of the Institute of Electrical and Electronics Engineers (IEEE) Council on Ocean Engineering. He also gave a series of lectures on spectral estimation and underwater acoustics at the Lisbon Technical University.

Professor Alexander Carmichael is a member of the Governor of Puerto Rico's Committee of Scientists and has had extensive discussions with faculty from India, Ireland, and Holland on teaching innovation.

Professor Chryssostomos Chryssostomidis is co-chairman of the Conference on Behavior of Offshore Structures to be held at MIT in 1982.

Professor Ira Dyer was awarded the Meritorious Public Service Medal by the US Coast Guard. He was also elected a Fellow of the American Association for the Advancement of Science, and was a keynote speaker at the International Underwater Acoustics Symposium in Tel Aviv, Israel.

Professor Judith Kildow is a member of the Board of the Law of the Sea Institute.

Professor Masubuchi was one of three special lecturers at the International Conference on "Welding Research in the 1980s," organized by the Welding Research Institute of Osaka University.

Professor John Newman presented special lectures at the University of Adelaide, Australia and at the University of Bristol, England.

Professor de Oliveira was appointed the Esther and Harold Edgerton Assistant Professor of Ocean Engineering for two years, beginning July 1, 1981. He also lectured at the Catholic University of Rio de Janeiro, the São Paulo Technical Research Institute, and the Lisbon Technical University.

Hart Nautical Museum

After many years of dedicated service, William Baker, the curator of the Hart Nautical Museum, retires effective July 1, 1981. The Museum is known the world over as a fount of information on the history of marine technology, a reputation due in no small part to the energy and intelligence of the present curator.

The connection between the Department and the Museum is unusual but important. It is a display area for current activities in ocean engineering, a repository of marine technology as it has developed over time, a focus and source of information for students, alumni, and friends of the Department, and a springboard for various subjects of instruction, most particularly during Independent Activities Period.

We are making plans for the curator's succession. We believe the successor should be someone with a strong interest in ocean engineering, hopefully one who could add materials in offshore technology to our outstanding collection in ship technology. We are also exploring more formal connections between the Hart Nautical Museum and other MIT museum activities. Informal connections have existed in the past, but as we look ahead it seems wise to make all possible use of the wider range of museum professionals now at MIT.

IRA DYER

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Center for Advanced Engineering Study

The need for continual learning opportunities, especially in the engineering profession, continues to be recognized in the United States and throughout the world. The Center attempts to meet the need through three different kinds of offerings and a program of research and development to create new offerings.

The Advanced Study Program is now space-limited and must turn away qualified applicants. The Self-Study Program, based on videotaped courses, continues its spectacular growth and is the largest of its kind in the world. Our newest area, Conferences, Seminars, and Short Courses, this year coordinated an increased number of meetings in a variety of technical areas, both on and off campus.

Our Research and Development Program includes Project TRANSMIT which is supported by both government and industry.

The Center also is conducting a Department of Energy-sponsored research project in complex thermoeconomic systems under the direction of Professor Myron Tribus and Dr. Yehia M. El-Sayed.

THE CENTER'S PROGRAMS

Advanced Study Program

This is an on-campus program that enables engineers and scientists to work in depth in technological areas of their choice. The Program serves technical managers who wish to understand developments that bear directly on their problems, men and women who seek competence in depth at technological frontiers, and those who desire to strengthen their technological base. This year there were 71 Fellows from 20 countries. The Advanced Study Program is directed by Dr. Paul E. Brown.

Fellows of the Program are affiliated with the Center for one or more terms. They may develop courses of study to meet their individual needs or may participate in specialized programs such as the Advanced Study Program in Air Transportation or Education for Public Management.

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.

Grades are recorded for all MIT subjects taken for credit. A certificate is awarded following satisfactory completion of a Program. Fellows also may apply for admission to the MIT Graduate School.

This summer we are offering a seven week intensive course on "Air Transportation -- Management, Economics, and Planning," jointly with the Flight Transportation Laboratory of the Department of Aeronautics and Astronautics. The course meets all day, five days a week. There are also evening sessions. Twenty-five men and women from 17 countries are attending the course.

Self-Study Program

MIT Video Courses are now being distributed in all international television formats. It is anticipated that, among others, Digital Signal Processing, the most widely used MIT Video Course will be utilized in PAL and SECAM transmission standards in Western Europe during 1981.
Fiscal 1981 has been the most active production year to date. The following courses have been developed: Microprocessors for Managers, Finite Element Methods in Structural Engineering, Advanced Tribology, Electronic Feedback Systems, Fluid Dynamics, and an updating of Artificial Intelligence.

The production schedule for fiscal 1982 is similarly dynamic. Courses planned for production include: Digital Electronics, VLSI Systems, and Digital Speech Processing. Courses being considered for development include: Transportation Systems Analysis, Superconducting Magnet Technology, Statistical Applications of Quality Control, and the Management of Technology.

The 800 studio-produced, broadcast-quality videotapes grouped into more than 40 comprehensive courses now reach over 20,000 students worldwide annually.

Conference, Seminar, and Short Course Program

The Seminar and Conference Office was established in 1977 to provide professional marketing and logistical support for the growing number of technical continuing education conferences, seminars, and noncredit short courses at MIT. While the majority of programs offered through the Seminar Office are sponsored by the School of Engineering, the Office is prepared to handle continuing education programs from any area of science and technology, and is designed to coordinate these programs on and off campus -- in the United States and throughout the world. The Seminar Office has received the approval of both Engineering Council and Academic Council as a recognized office of continuing education at MIT.

The heavy demand for continuing education offerings has resulted in a growing number of programs at MIT. A few of the 1980-81 programs included: "Fusion Energy: Can We Have It? When?" sponsored by the Department of Nuclear Engineering; "Climate and Risk" sponsored by the Center for Advanced Engineering Study; "Macro-Engineering" sponsored by the School of Engineering; "Finite Elements" sponsored by the Department of Aeronautics and Astronautics; "Economic Regulations of Air Transport" sponsored by the Department of Aeronautics and Astronautics; "Nuclear Power: Challenge for Journalists II" sponsored by the Department of Nuclear Engineering; "Corporate Productivity Improvement -- A New Managerial Investment" sponsored by the MIT Medical Department and the Laboratory for Manufacturing and Productivity; "The 22nd US Symposium on Rock Mechanics" sponsored by the Departments of Civil Engineering, Mechanical Engineering, and Earth and Planetary Sciences; "Statistical and Probabilistic Methods in Rock Engineering" sponsored by the Department of Civil Engineering; and "Remanufacturing in the 1980s" sponsored by the Center for Policy Alternatives.

During 1980-81, more than 20 foreign countries and 45 states in the US were represented at continuing education offerings from the Seminar Office. The 200 percent increase in requests for program information is an indication of the interest in continuing education meetings. Therefore, the number of program offerings is certain to increase substantially during 1982.

Project TRANSMIT

Project TRANSMIT (To Research and Study Modes of Information Transfer) was launched as an attempt to discover the effectiveness of various modes of transferring information. Comparisons of live, audio cassette, print, on-line, and microfiche presentations of various levels of technical information were made involving the entire membership of the American Institute of Chemical Engineers (AIChE). Perhaps the most intriguing aspect of this multifaceted Project involves defining effectiveness as an increase in on-the-job productivity, rather than the amount of information retained or learned. This represents a radical departure from most approaches measuring the effectiveness of educational programs, and the results obtained so far hold a good deal of promise for practical application in industrial settings.

To date we have completed a two-year study of the impact of more than 180 talks delivered and made available to the AIChE membership simultaneously in the five modes mentioned above. We have tracked the impact of those lectures or talks in the modes presented. We have related six-month follow-up findings to various job and background variables. We have learned many isolated facts about effectiveness in information transfer. Perhaps the most interesting
The general fact that we have established is that more than 70 percent of the individuals involved felt that they had acquired useful information and that half of them had actually used that information on their jobs by the end of the six-month follow-up period.

The practical results and implications of the work we are doing are quite varied. We have learned a good deal and hope to learn more about effective placement and types of approaches for designing training programs. We hope to help companies arrange their offerings and resources so that they will be easily accessible and satisfying to use. We are hoping to offer new insights and emerging hypotheses as to modes of information transfer which can improve the efficacy and impact of communications and education efforts.

Our hopes for future work are to do detailed case studies of actual information use and transfer without leaving the work site to attend a professional society meeting. We hope that the participating companies would gain individually from an intensive analysis of the effectiveness of their offerings in terms of their primary productivity and educational goals and standards. We also hope that we would be able to arrive at some general and generalizable conclusions regarding these processes which would be useful to all industries attempting to improve the understanding and performance of people on the job.

The Project is directed by Dr. Karen C. Cohen.

Thermoeconomics

This research project is concerned with the development of a new discipline in which the principles of thermodynamics, engineering economy, and optimization are combined and applied to the analysis of systems which convert or use energy.

The aim is to develop an approach similar in philosophy to the conventional approach to the thermodynamic analysis: to stimulate creative designs of systems, as well as to develop an analytic method of improving the allocation of capital and energy resources within a system.

MYRON TRIBUS

Center for Policy Alternatives

Technology and engineering have effects on almost every facet of modern life. One of the major problems of our time is the delineation of these effects and the policy choices they present for decision makers in government, industry, the labor movement, and academe. MIT's continuing commitment to this constructive criticism of the technological enterprise is exemplified in the work that is carried out at the Center for Policy Alternatives (CPA). Since its founding in 1972 by Dr. J. Herbert Hollomon, CPA has been studying complex sociotechnological problems and suggesting alternatives for decision makers. CPA has been particularly concerned with industrial innovation -- the way new technology is developed and introduced -- and with the government policies that affect innovation.

During the past academic year CPA continued its specialization in technology and public policy; regulation and technological change; environmental, health, and safety regulation; technology transfer; manufacturing technology and industrial productivity; and office automation and communication systems.
RESEARCH

Technology and Public Policy

Over the years CPA researchers have studied the industrial and technology policies of Israel, Brazil, Venezuela, the United Kingdom, and several countries in Europe. Through this work CPA has developed unique approaches to analyzing industrial sectors, private and public science and technology institutions, and government policies that support or hinder industrial innovation. During the past fiscal year CPA began a major study of Portugal's technological infrastructure, completed a study of technological innovation in Korea, and continued research on Sweden's technology policies.

CPA's study of Portugal's technology development policies, which began in April and will continue for 18 months, is being carried out in collaboration with the Laboratorio Nacional de Engenharia e Tecnologicas Industrial (LNETI) of Portugal, and will provide background data and analysis for Portugal's technology development plan. The project team, led by Dr. K. Nagaraja Rao, principal investigator, is analyzing the incentives and disincentives that promote and hinder Portugal's technological capability and is preparing a plan of action to modernize Portugal's technological infrastructure. The study is sponsored by LNETI and is partially funded by a World Bank loan to Portugal for the development of small- and medium-scale industry. Project participants include Dr. Christopher T. Hill, Visiting Scholar Joseph Bredie, Professor Raymond Baddour of the Department of Chemical Engineering, and Visiting Research Specialists Thomas Schmitt and Thomas Maier.

In a similar project, completed at the end of February, CPA researchers investigated Korea's technology policy. This project was a collaborative undertaking between CPA and the Korea Institute of Science and Technology (KIST). It was supported by the United Nations Development Program (UNDP) by means of a project grant to Korea's Ministry of Science and Technology, and the World Bank acted as the project's executing agency. CPA's Korea research team, led by Principal Investigator Dr. Hollomon and Project Manager Dr. Rao, concluded that there was an urgent need for new mechanisms to encourage the upgrading of technology in Korean industry -- especially in small- and medium-size firms -- and that there was a need for concurrent support of research, development, and engineering in large and small technology-intensive enterprises. The CPA study recommended the formation of a new type of financial intermediary, which would provide noncollateralized loans to existing industry for the "software" components of technological upgrading and would also take equity in new technology-based companies. The Korean parliament passed legislation in early 1981 reflecting CPA's recommendations, and the Korean Technology Development Corporation was later established. Project participants from MIT included Dr. Hill, Dr. James Utterback, Professor Baddour, Professor Koichi Masubuchi of the Department of Ocean Engineering, and several graduate students.

A third study of technological development is being carried out in collaboration with Sweden's technology policy agency, the National Swedish Board for Technical Development (STU), and is designed to suggest alternative policies and programs that would provide the most satisfactory environment for industrial innovation and change in Sweden. This is a two-year program with the possibility of extension to a third year. It is headed by Principal Investigator Dr. Utterback and was undertaken by CPA after several years of exploration between CPA's director and officials at STU. Project participants are studying the interactions among established Swedish firms, new Swedish firms, US firms, the Swedish economy, STU, and technology. An interim report, to be completed in September of 1981, will analyze Sweden's new technology-based firms, STU's technology support program, and communication among people in technology research and development, universities, and research institutes. Dr. Andrew Martin is currently working full time on the project; other CPA participants include Dr. Rao and Visiting Professor Burton Klein from the California Institute of Technology. MIT faculty who are involved in the research include Professor Edward B. Roberts, Professor Thomas J. Allen, Jr., and Professor Dorothy Leonard-Barton, of the Sloan School of Management; and Professor Harvey M. Sapolsky of the Department of Political Science.

Regulation and Technological Change

For the past two years, CPA has been studying regulation and the automobile industry. One project ended in April, when work sponsored by the US Department of Transportation (DOT) was completed; another project, sponsored by the US Environmental Protection Agency (EPA),
is expected to be completed at the end of September. In recent months, CPA has broadened its investigation of automobile policies and has become involved in the Future of the Automobile Program, sponsored in part by the German Marshall Fund.

The research sponsored by DOT examined the responses of automobile firms in Germany, Sweden, and Japan to US regulations on emissions control, fuel economy, and safety. The project team also investigated the technological responses of automobile firms to government support for the development of automotive technologies. The experience of these countries indicates that compliance with regulation, in both the US and abroad, is not incompatible with corporate strength or a healthy automobile industry.

In the automobile research sponsored by EPA, CPA is investigating regulatory and nonregulatory programs that are used abroad to control the adverse environmental impacts of the automobile and analyzing the development of emissions control technology. Both elements of this study are being undertaken with the goal of deriving conclusions that are relevant to the formulation of future US policies. Participants in CPA's automobile program include Principal Investigator Dr. Nicholas A. Ashford, Project Manager George R. Heaton, Jr., Dr. Hill, Dr. W. Curtiss Priest, and Richard F. Andrews.

This past spring several CPA researchers began participating in the Future of the Automobile Program with researchers at MIT's Center for Transportation Studies and Center for International Studies to explore long-range, global policies toward the automobile. Visiting Professor Klein, Dr. Utterback, graduate student Joan DoPico, and Harvard Business School Professor William Abernathy are examining public and private measures aimed at ensuring a viable automobile industry and are investigating automaker's efforts to evolve smoothly when faced with new circumstances. Mr. Heaton and Mr. Maxwell are studying social policy toward the automobile.

Phase II of a National Science Foundation-sponsored project to examine relationships between regulation and technological innovation in the pharmaceutical industry began in March. The project team, which includes Principal Investigator Dr. Ashford, Project Manager Dr. Dale Hattis, Mr. Andrews, Dr. Priest, and Dr. J. Worth Estes of Boston University Medical School, is conducting in-depth case studies of regulation/innovation relationships within three therapeutic classes (systemic antibacterials, antihypertensives, and antidepressants). These case studies include a systematic examination of the effects on innovation of US regulatory "signals" sent from the Food and Drug Administration to drug companies for drugs in each therapeutic class since 1962. In addition, comparisons are being made between US and foreign drugs in the three therapeutic classes.

In September, CPA began a year-long project funded by the Office of the Assistant Secretary for Policy Evaluation and Research of the US Department of Labor to study the productivity response of industry to occupational asbestos regulation. This retrospective study will document the technological and productivity changes that occurred in 40 firms in response to asbestos regulation. The impacts of regulation on production are being traced to operating costs, capital expenditures, medical monitoring, hygiene, product substitution, and product elimination. Productivity impacts will be shown in relation to the costs of production at the plant and in relation to the total value added costs in final consumption. Project participants include Dr. Ashford, principal investigator, and Dr. Priest, project manager.

In a project funded by the NSF, Dr. Hill, principal investigator, and Mr. Andrews are examining the effects of technological innovation, technology choice, and regulatory design on regulatory compliance costs. Their research, which focuses on the effects of the Clean Water Act, the Clean Air Act, and the Resource Conservation and Recovery Act, is expected to be completed at the end of October.

Environmental, Health, and Safety Regulation

In an 18-month sequel to the pilot study done for the Senate Committee on Governmental Affairs, a team of CPA staff and consultants has nearly completed a major study of methodologies and considerations in assessing the benefits of environmental, health, and safety regulations. (The pilot study was published in March 1980 by the US Committee on Governmental Affairs as Benefits of Environmental, Health, and Safety Regulation.) In recent months, with the growing requirements and expectations for the use of cost/benefit analysis in environmental policy, it has become even more important to formulate better and more comprehensive approaches to the estimation of regulatory benefits.
In this study, funded by a consortium of US regulatory agencies through EPA, the emphasis has been on expanding the range of methodologies and considerations beyond those commonly used in benefits analysis. The project team, led by Co-Principal Investigators Drs. Ashford and Hill, has addressed organizational issues, such as the extent of agency implementation and the degree of industry compliance that can be expected to affect the flow of benefits and costs of a regulation. Researchers have also examined the implications of different health, accident, and environmental damage models for benefits analysis. Considerable attention has been given to systematizing consideration of the intangible aspects of regulatory benefits such as the individual, community, and social benefits of avoiding injury, disease, and loss of life. Finally, members of the research team have been considering the ancillary benefits of regulations that transcend the reductions of risk to health, life, and the environment. Project participants include Dr. Priest, Dr. Hattis, Dr. William Mendez, and Mr. Andrews.

Another project that is based on prior CPA research is being funded by the National Institute for Occupational Safety and Health, the agency that provides research for the Occupational Safety and Health Administration (OSHA). In this work Dr. Hattis is testing a pharmacodynamic model for occupational exposure to airborne lead. CPA used the model in 1977-78 when it assisted OSHA in assessing the costs of the proposed medical removal protection provisions of the occupational exposure standard for lead. The early phases of OSHA's medical removal protection provision have now been in place since 1979, and recently submitted data from industry allows CPA to test the model's accuracy and suggest improvements in it. Dr. Ashford is principal investigator for the project.

Other work funded by OSHA was completed in April, when CPA finished a case study assessing the health benefits and economic costs of alternative types of regulation for the control of occupational exposures to formaldehyde. Dr. Hattis was project manager and Dr. Ashford was the principal investigator.

CPA recently entered into a three-year cooperative agreement between CPA/MIT and the Office of Toxic Substances at EPA. This project, led by Principal Investigator Dr. Ashford, is designing strategies for the identification, testing, and control of toxic substances. Participants in the project will include members of the Department of Chemical Engineering and the Department of Nutrition and Food Science.

Technology Transfer

Robert T. Lund and Richard S. Goldhor recently completed a study of university-to-industry technology transfer in a project sponsored by the NSF. The research analyzed the transfer of a highly sophisticated computer software system from MIT to a small, high-technology company in California, Telesensory Systems, Inc. (TSI). The transfer was successful, and TSI eventually used MIT's software, in conjunction with its own, to develop a text-to-speech reading machine for the blind. The events in this process were compared to traditional technology transfer models, and from this analysis, Mr. Lund and Dr. Goldhor concluded that familiarity with such models could have eased the transfer process for both MIT and TSI. Existing models of technology transfer, most of which were developed with low-technology recipients in mind, were modified to account for technology transfer from universities to high-technology recipients.

The sequential process of the transfer of military technology from developed to developing countries, from the defense to civilian sectors within developing countries, and from developing countries to world markets was investigated in a seven-month study completed in August. This project, which was sponsored by the United Nations Disarmament Center and led by Dr. Rao and Professor Jack Philip Ruina of MIT's Center for International Studies and Department of Electrical Engineering, explored the possible economic returns from military industries in developing countries. In a case-study format, the project team examined the development of the military aircraft industries in Brazil, Israel, and India -- the only three developing countries that now have substantial aircraft industries.

One conclusion of the project is that the overall impact of defense programs on a country's economy is highly dependent on the politics, organization, and values of the country. The military aircraft industries in Brazil and Israel have diversified their product lines to include civilian products, and have successfully exploited world export markets for both military and civilian products. In contrast, the sole producer of aircraft in India is fully owned by the government, and most of its production is for the Indian Air Force.
The United Nations Development Program sponsored Dr. Rao's participation in a conference, "Technology Choice and Transfer in the Electronics Industry," held in Utrecht, the Netherlands in May. The conference focused on labor-intensive manufacturing processes that developing countries can use in assembling electronic products and on measures to assure the quality of finished products. It was hosted by the Philips Corporation of the Netherlands at their pilot plant in Utrecht, where Philips demonstrated how developing and developed countries can collaborate in transferring electronic technologies. Representatives from 15 developing countries attended the conference.

Manufacturing Technology and Industrial Productivity

In April CPA researchers completed a one-year exploratory project, managed by Principal Investigator Mr. Lund, to assess the needs and opportunities for computer-aided materials processing in primary shape forming of metals -- particularly casting, forging, extrusion, and powder metal processes. The Computer-Aided Materials Processing (CAMP) Project was sponsored by the National Aeronautics and Space Administration (NASA) and carried out jointly by CPA and the Materials Processing Center at MIT. The investigation took the form of three workshops in which people from industry, government, and academe -- representing a range of disciplines related to materials processing, machine intelligence, and automation -- took part. Based on the workshops, the project team developed an overview of the present status of industrial materials processing practices, described recent technological advances, and outlined a cooperative program for industry, university, and government cooperation on computer-aided materials processing. Workshop participants from MIT included Professors Merton C. Flemings and Nicholas J. Grant, of the Department of Materials Science and Engineering; and Professors Thomas B. Sheridan and David E. Hardt, of the Department of Mechanical Engineering.

Phase II of CPA's program on remanufacturing, sponsored by the US Department of Energy, was completed in March, and work on Phase III began recently. Remanufacturing is the full-scale disassembly of products, pooling of interchangeable parts, and production-line reassembly in a manner similar to the original manufacturing process, with some replacement of work parts; the process restores products to a point where they meet or exceed original performance specifications. CPA's remanufacturing research is the first in-depth examination of this industrial activity. During phases I and II, CPA researchers under the direction of Principal Investigator Mr. Lund obtained a comprehensive overview of the structure of present US remanufacturing activities, the operating characteristics of firms in the industry, and the energy and resource conservation potential inherent in remanufacturing. The study included a national survey of all known remanufacturers.

Phase III of the remanufacturing project is a preliminary engineering feasibility study that will serve as a vehicle to interest people in making commitments to commercially viable, privately financed remanufacturing operations. The project team is investigating the technical feasibility and requirements of remanufacturing three selected products; and they will study the economic benefits, energy conservation implications, and legal and regulatory constraints of remanufacturing the products. Project participants include Research Specialists Ronald Grand and Lynn Bollinger, Professor Joel P. Clark of the Department of Materials Science and Engineering, and Visiting Scientist Floyd Tuler.

In February CPA completed a study sponsored by the Bureau of Consumer Protection of the Federal Trade Commission on the reliability and durability of major household appliances, such as refrigerators, freezers, and washing machines. The study was conducted by Mr. Lund, principal investigator, and Professor Michael Denney, who is on leave from the University of Texas at Austin and is currently associated with the Survey Research Center at the University of California in Berkeley. The specific question CPA addressed was whether prospective reliability and durability tests are being performed in the US household appliance industry to forecast the frequency and timing of product failure and expected product life.

With one minor exception, CPA researchers found that there are no prospective tests for product reliability or durability in use in the household appliance firms that were studied. These firms do perform a number of quality tests, both on components and on assembled products, but none of these tests were designed or validated to predict timing, frequency of failure, or product life.
Another project that investigates product lifetime prediction is being sponsored by the Army Materials and Mechanics Research Center. This is an exploratory study to examine the possibility of using product life forecasting techniques to establish maintenance and replacement routines for Army weapons systems. Knowledge gained from this research should provide understanding of product lifetime prediction in the civilian sector.

Currently, methods for determining when components of a military weapon system should be overhauled or rebuilt tend to be based on somewhat arbitrary rules, such as operating time or calendar time. Little has been done to ascertain whether the rules are technically appropriate or economically efficient. Because of the enormous investment in capital equipment in the Army, even small savings in overhaul and rebuild costs or in prolonging the service life of equipment could save millions of dollars. Participants in this project include Mr. Lund, principal investigator, and Dr. Tuler.

One phase of research in the Advanced Technology and Productivity (ATIP) Program will end in November, when a case study of the introduction of automated machine systems in a tractor components manufacturing operation (at Caterpillar Tractor Company) will be completed. The ATIP Program is a cooperative venture between MIT/CPA and a group of participating firms to explore the impacts of computer-based automation of manufacturing organizations and their employees, products, and operating results. Participating firms provide both funding and research sites for the program. Mr. Lund is principal investigator of the ATIP Program.

Office Automation and Communications Systems

A program that parallels CPA's ATIP Program, the Office Technology and Productivity (OTAP) Program, examines the impact of automation on offices and office workers, similar to the way ATIP examines automation's impact on manufacturing processes and workers. The OTAP Program began in January and is a long-term project designed to be a cooperative venture between MIT, industrial firms, and government agencies to address, through longitudinal research, the full range of impacts of office technology on user organizations. OTAP's initial sponsor is IBM.

In the OTAP program's first study, Co-Principal Investigators Dr. Marvin A. Sirbu and Professor Michael Hammer of the Department of Electrical Engineering and Computer Science are comparing a sample of IBM offices that are undergoing automation with a sample of offices remaining on manual systems. Data is being collected before new technology is introduced, and will be periodically collected for up to two years. The OTAP Program will benefit from CPA's parallel ATIP Program and from Dr. Sirbu's work at the Laboratory for Computer Science, where he is currently performing research on office specification and analysis methodologies.

EDUCATIONAL ACTIVITIES

Students perform a major role in CPA research and are involved in most projects undertaken at CPA. This involvement provides students with training in policy formulation and analysis and also enriches CPA research with fresh perspectives. During the past academic year, 42 graduate and undergraduate students from MIT and other universities participated in CPA research.

Many of the MIT graduate students who work at CPA are master's candidates in the Technology and Policy Program (TPP), a special interdepartmental program in which students take courses in economics, law, government, and a technical concentration of the student's choosing. Since the program's founding in 1976 by Dr. Hollomon and Dr. Jerome Weisner, many TPP students have received policy analysis training at CPA.

During the past academic year, CPA staff members developed three graduate courses that will be offered in the new master's degree program in the Management of Technology. The program begins in June of 1981 and is sponsored jointly by the Sloan School of Management and the School of Engineering.
Dr. Hollomon, Mr. Heaton, Dr. Hill, and Dr. Ashford initiated and planned a course in Government and the Management of Technology. This seminar will be offered for the first time during the fall semester and will examine the changing role of government in shaping and directing the management of technology in the civilian sector of the economy.

Dr. Utterback and Professor Robert D. Logcher of the Department of Civil Engineering have developed a course in Technology Planning, which will be offered in the fall. Dr. Utterback and others are developing a course, Manufacturing/Technology Interface, which will be taught during the spring semester.

Twelve other subjects are taught by CPA staff members. The staff also supervises the research and academic programs of bachelor's, master's and doctoral candidates. During the past academic year, 22 theses were completed under the direction of CPA staff members.

INFORMATION DISSEMINATION

During the past year, CPA published the first two issues of a new publication, Policy Choices: A Review Discussing Technology, Engineering, and Social Policy. Policy Choices is a twice-yearly publication, appearing in the fall and spring, and its purpose is to report on current activities at CPA and to stimulate discussion among people in government, industry, education, labor, and public interest groups on the role of technology and engineering in society. Response to the first two issues was enthusiastic, and requests for CPA reports tripled soon after the first issue was published. The publication is supervised by Mr. Heaton, and edited by Pat Harrison.

Another forum for discussing CPA research issues is the Center's luncheon seminar series which began in June 1980. The informal luncheons feature lecturers from MIT and other universities, as well as government officials and authorities from abroad. Ten seminars were held during the past academic year, among them, presentations by Keith Pavitt of the University of Sussex in England, Marvin Schneidermann, formerly of the National Cancer Institute, and Bengt-Arne Vedin of the Business and Social Research Institute in Stockholm. The presentations by Mr. Pavitt and Dr. Vedin were later adapted into articles that appeared in Policy Choices.

A new information dissemination tool was recently designed by Dr. Priest for use in CPA research projects and for licensing to other institutions. CPA's new Bibliographic Management System, a computer-based storage and retrieval system for bibliographic citations, has produced seven bibliographies that are available through CPA's Document Collection, and the system program is now being licensed to other institutions. To date, bibliographies have been produced on automobiles, the benefits of regulation, transportation, toxic substances, innovation, technological development in Portugal, and technological development in Sweden. CPA's documents coordinator, Marilyn Reisse, demonstrates the system to users and explains its capabilities.

PUBLIC SERVICE ACTIVITIES

In designing and assessing policy alternatives for both national and international leaders, CPA's research is practical and action-oriented. During the past year, staff members continued to serve on public committees and testify before Congress on public policy issues. In addition, several staff members served as advisors and consultants to private firms, labor organizations, and public interest groups.

In September, Dr. Hollomon testified on the National Technology Foundation Act of 1980 before the Subcommittee on Science, Research, and Technology of the Committee on Science and Technology.

Dr. Ashford testified in March before the Consumer Product Safety Commission on its proposed method for determining unreasonable risk under the Consumer Product Safety Act. He also testified before the Senate in May on the proposed Regulatory Reform Act of 1981. Dr. Ashford continued his work as chairman of the National Advisory Committee on Occupational Safety and Health and as a member of the Science Advisory Board of the US Environmental Protection Agency.
was recently elected a Fellow of the American Association for the Advancement of Science. Dr. Ashford was a member-at-large of the American Public Health Association's Program Planning Committee for its 1981 annual meeting and, during the past year, was elected vice president of the Society for Occupational and Environmental Health. He continued to serve as a member of the US General Accounting Office's Advisory Panel on Drug Approval Processes, as a member of the American Lung Association's Occupational Health Committee, and on the American Chemical Society's Committee on Health and Safety.

Dr. Utterback continued to serve on the National Academy of Engineering Panel on Very High Speed Integrated Circuits. He also continued his work as US editor for Research Policy, an international quarterly journal published in Amsterdam and devoted to research policy, research management, and planning.

Dr. Rao served on the Executive Committee of the VII Inter-American Conference on Materials Technology. He serves as a member of the Long-Range Planning Committee for the International Division of the American Society of Engineering Education. Dr. Rao continued his work on the ad hoc MIT Committee on Boston School Desegregation. In June Dr. Rao presented a paper, "Food Processing Technology in the Developing World: Issues and Institutions," at the 41st annual meeting of the Institute of Food Technologists, held in Atlanta. Dr. Rao will present a paper by himself, Dr. Hill, and Dr. Baddour at the Second World Congress of Chemical Engineering and World Chemical Exposition, which will be held in Montreal in early October. The paper is on "Strategic Aspects of Chemical Industry Development in the Rapidly Industrializing Nations."

In November, Dr. Hattis served as a panel member at the Massachusetts Consumers' Council Conference, "Asbestos Strategy for the 1980s -- Medical, Legal, and Consumer Issues."

In December, Mr. Heaton was appointed to the National Research Council Motor Vehicle Nitrogen Oxide Standard Committee.

Dr. Priest presented testimony in April by himself and Dr. Ashford before the Subcommittee on Labor Standards of the House Committee on Education and Labor. Dr. Priest outlined for the subcommittee the costs of not regulating occupational health hazards. In September Dr. Priest attended the Organization for Economic Cooperation and Development conference on science and technology indicators, and presented results from his recent work for the NSF on "Identifying and Assessing Discrete Technological Innovations: An Approach to Output Indicators." In a letter to the editor of Business Week, published in March, Dr. Priest drew on his work for CPA's automobile project to critique a Business Week article on the automobile industry.

Dr. Hill continued to serve as a member of the NSF's Advisory Committee on Policy Research and Analysis and Science Resources Studies. In August Dr. Hill prepared two papers for Organization for Economic Cooperation and Development, "Sources of Innovation in the Chemical Industry: Background to an International Assessment of the Impacts of Premarket Notification" and "Induced Beneficial Technological Innovation from Environmental Policy." Dr. Hill was recently elected treasurer of the new Division of Engineering and Public Policy of the American Society for Engineering Education.

Mr. Lund served on the National Bureau of Standards' Steering Committee for a Workshop on Improvement in Productivity in Metals Processing.

STAFF PUBLICATIONS

CPA staff members contributed to books, journals, and CPA reports during the past fiscal year. Some of these publications included the following:


**FACULTY, STAFF, AND STUDENTS**

CPA's permanent staff includes 11 research staff, three faculty, five temporary research specialists, three administrative staff, and 10 support staff. In addition to the permanent staff, 42 students and nine visiting researchers worked on CPA research during the past year.
Dr. Andrew Martin joined CPA in February as a principal research associate and is currently working on the Sweden project. He has taught political science at Columbia University, the University of Massachusetts, and Boston University, and has done comparative studies of economic policy at the Harvard University Center for European Studies.

Three CPA research associates -- Dr. Hattis, Mr. Heaton, and Dr. Priest -- were promoted to principal research associates.

June McClean and Ena Squires, formerly of CPA's administrative office, accepted positions in the Department of Earth and Planetary Sciences and in the Office of the Dean of Engineering, respectively. Candidates are now being recruited to fill their positions. Elaine Petrino, who formerly held an administrative position in the Department of Biology, is currently working in CPA's administrative office.

Dr. Burton Klein, an economist from California Institute of Technology, was a visiting professor at CPA until the end of June.

Joseph Bredie, formerly of the United Nations Education, Scientific, and Cultural Organization (UNESCO), was a visiting research fellow at CPA until the end of May, working with Dr. Rao on the Portugal and Korea projects.

Visiting Scientist Floyd Tuler, on leave from Hebrew University in Jerusalem, is working with Mr. Lund on the remanufacturing project and the life forecasting study.

For the sixth year, two graduate research interns from the University of Konstanz in Germany participated in CPA research. Ludwig Maier and Thomas Maier worked at CPA until late spring under the direction of Dr. Rao.

Peter Hofelich, a student from the University of Konstanz, worked at CPA as a research intern during the fall under the auspices of the German Academic Exchange Service.

Dr. Joel C. Novak, professor of sociology at the University of Winnipeg, was a visiting scholar at CPA during the past spring.

Two Korean officials, Song Ho-Jong of the Economic Planning Board and Kyung Jong-Chul of the Ministry of Science and Technology, visited CPA for a training program in late June and early July of 1980. The program of lectures and seminars was held to familiarize the Korean officials with the findings of CPA's study of technological development in Korean industry. Their visit was sponsored by the United Nations Development Program with the World Bank acting as the executing agency.

J. HERBERT HOLLOMON

Center for Transportation Studies

The Center for Transportation Studies (CTS) was established in 1973 to centralize and coordinate the wide range of transportation-related activities at MIT and to stimulate further efforts throughout the Institute. It provides a focal point for transportation education; facilitates transportation research; prepares, assembles, and distributes a wide range of information; and encourages a sense of common purpose among the disparate disciplines involved in the transportation field.

The Center is organized within the School of Engineering and is affiliated with 11 academic departments throughout the Institute. In addition to the director, it maintains a full-time research staff of nine and an administrative staff of six, with a total of more than 50 affiliated faculty and staff. This past October, a deputy director was added to the staff: Wilbert A. Pinkerton, Jr., a graduate of Carnegie-Mellon and the Harvard Business School with extensive experience in academia, government, and the private sector. Mr. Pinkerton's role, at least initially, will be to enhance the private sector activities at the Center, in both research and education.
The Center's activities are guided from an internal MIT perspective by its Executive Committee and from an external viewpoint by its Advisory Committee. Members of the CTS Executive Committee for 1980-81 were Professor Alan Altshuler (Head, Department of Political Science), Professor Ralph Gakenheimer (Urban Studies and Planning), Professor Thomas Magagnotti (Sloan School), Professor Marvin Manheim (Head, Transportation Systems Division; Civil Engineering), Professor Herbert Richardson (Head, Mechanical Engineering), Professor Robert Simpson (Director, Flight Transportation Laboratory; Aeronautics and Astronautics), and Professor Daniel Roos (Director, Center for Transportation Studies). The CTS Advisory Committee consists of 11 transportation leaders from industry and academia. The Committee is chaired by Denman McNear, Class of 1948, and President of the Southern Pacific Transportation Company.

RESEARCH

Research conducted and facilitated by the Center involves all modes of transportation, both passenger and freight, in both the public and private sectors. Efforts may vary from modest projects involving a single faculty member, to large-scale programs involving more than 20 people and including a full-time research staff. There are typically 50 research projects and two or more research programs under way at any given time.

During the past year, the Center has continued to expand its research efforts on problems and issues in the private sector. This is in keeping with the overall strategy, established two years ago, of developing a balanced mix of public- and private-sector activity in contrast to the Center's early years when research on public-sector issues was dominant. Also, expansion of private-sector, management-oriented research (and educational offerings as well) was one of the principal suggestions made by the CTS Advisory Committee at its meeting in October. In particular, the CTS Research Program in Railroad Operations and Economics was viewed as a good model for future programs in other modes.

The Rail Program began in 1970 with a small study of rail operations and line-haul reliability. Since then, the program has involved government agencies, industry associations, and many of the nation's railroads -- large and small. It has resulted in more than 30 theses and research reports, development of a comprehensive model for railroad service planning, and, in the most extensive of more than 20 case studies, annual savings of more than $3 million for the Boston and Maine Railroad. The research has ranged from detailed analyses of operations with a series of computer models, to appraisal of the effectiveness of alternative organizational structures in today's railroad environment. While the Rail Program continues to explore new areas, efforts are under way to develop a similar program in the motor carrier industry.

Another of the Center's major research undertakings is the International Study on the Future of the Automobile, a multimillion dollar program consisting of coordinate research investigations and international workshops to explore future policy options for guiding auto technology in socially desirable directions. The research is being directed by the Center for Transportation Studies in conjunction with the Center for International Studies at MIT, with a network of research teams in Germany, France, England, Sweden, Japan, and the United States.

In November, coordinators for all the research teams convened at L'Institut August Comte in Paris to report on the status of their efforts and to discuss the research program and the international policy forums which will link the program to the public and private arenas in which major decisions are made. The forums will use research results to explore future policy options, and discussion at the forums will, in turn, influence research directions.

It was agreed that the research program would consist of four main parts: Government Policy-making and Implementation will examine government policies and how they differ from country to country. Industry Structure, Corporate Strategy, and Labor Relations will focus on the decision-making process in the automotive industry and distribution system. Technological Opportunities and Uncertainties will focus on the opportunities for product and process improvement that are likely to be available over the next two decades, and on their potential consequences. Lastly, Automobile Usage Strategies will focus particularly on strategies that have been used (or have been considered for use) in conserving energy, enhancing safety, and/or reducing air pollution. All of the research teams reported progress in identifying research projects, collaborators, and potential funding sources, and in obtaining modest start-up grants.
Funding for the US program, and for program coordination, has been augmented during the year, and additional sponsors have been engaged. Last fall, the German Marshall Fund approved an increase in their October 1979 start-up grant of $300,000 to $462,000 in the fall of 1980. In December, the US Department of Transportation (DOT) awarded the program $150,000 for the investigation of institutional factors shaping US industrial society. And the Eli Lilly Endowment, Inc., approved a major grant this spring totaling $766,000 over three years to MIT, with a similar grant to Purdue University for a collaborative program of research. Several other proposals are currently under consideration at other agencies and foundations for support of both the general program and specific research projects.

The first of the policy forums was held this June at Eagle Lodge, near Philadelphia, and featured 35 people holding key industrial, government, and academic positions. Participants were drawn from each of the countries collaborating in the research program to represent the points of view of industry, labor, government, energy, technology, safety, the environment, supply, and auto usage. Other forums are schedule for April 1982 in Tokyo, January 1983 in Brussels, and September 1983 in Detroit, where the policy forum participants will present their findings and recommendations, which will then be published in book form.

Other major research activities during the year included a cluster of six studies, sponsored by the Transportation Systems Center of DOT, on subjects ranging from Community Analysis in Urban Transportation Planning to Fatigue Performance of Railroad Rails, and a three-year grant from the Urban Mass Transportation Administration's University Research and Training Program for research on short-range transit planning. A three-year program of cooperative education and research, funded through the Brazilian Ministry of Planning, began officially in March when 80 Brazilian professionals convened in Brasilia for a two-week MIT course on the Fundamentals of Transportation Systems Analysis. The second course in the series is slated for 1982. Research projects have also been initiated in Brazil on urban travel demand and energy policy. The Center also has a continuing involvement in Egypt as part of the MIT Technology Adaptation Program, assessing the possible impacts of alternative transportation policies on that country's development.

Over the Center's seven-year history, the volume of the research program has increased from $0.1 million to a 1981 total of $1.9 million, with an estimated volume of $1.5 to 2 million or more in 1982. While the volume has risen, the mix of sponsors has also changed. In 1977, nearly half of the work was sponsored by DOT, but this year, they sponsored less than one-third of the work, with the US Department of Energy sponsoring 25 percent, and non-profit foundations and private sources accounting for 27 percent. It is anticipated that the diversification and proliferation of funding sources will continue, with particular emphasis on foundations and private sector sources.

EDUCATIONAL PROGRAMS

In 1979-80, the Center initiated a new interdepartmental master's program to provide the multi-disciplinary understanding and expertise needed to deal with today's complex transportation problems. Since the introduction of that program, the number of applications to study transportation at MIT has increased by almost 25 percent. The number of women applying has increased from eight percent of the total to a current 32 percent. Approximately two-thirds of all successful applicants come directly from undergraduate school, while the rest come from a variety of positions in industry and public service. Of those who have determined their specializations thus far, 50 percent have chosen urban transit/public transport. There are 32 students now enrolled, with 21 more expected in the fall. Nine have graduated to date.

The curriculum of the master's program consists of a set of six core subjects with elective subjects in 11 program areas. So far, curriculum development has been focused on core subjects, texts, and advanced follow-up courses. Strong course sequences now exist in many of the program areas, and further development is under way in the areas of transportation management, freight transportation, transportation technology, and transportation in developing countries.

Each year the Center also sponsors a Special Studies Program as part of MIT's Summer Session, offering working professionals the chance to keep up with new developments in their field and to acquire new techniques specific to their needs. Students have come from around the world, and some CTS/MIT faculty have also taught portions of the program in Israel, Japan, Switzerland, Spain, Brazil, and the Netherlands.
The courses to be offered this year are: Transportation Systems Management and Analysis; Port Management, Planning, and Development; Railroad Operations, Planning, and Management; Motor Carrier Marketing Under Deregulation; Public Transportation Service and Operations Planning; Urban Transportation; and Forecasting Transportation Demand. Included in the courses are case studies, lectures, and speakers from industry and government.

The Affiliates of the Center for Transportation Studies

One of the top priorities of the Center is the development and strengthening of ties between the Center and private-sector organizations, in both research and education. This spring, culminating more than two years of planning, the Center initiated the Affiliates of the Center for Transportation Studies to provide a structure for the growth and development of such relationships.

Under the general direction of the new deputy director, the Affiliates Program will provide its members with ongoing access to the Center's research and education programs, including the opportunity to participate in research of mutual interest. The research supported by the program will contribute significantly to the development of improved educational programs for private-sector managers.

Initially, executives of Affiliate firms and organizations will be invited to attend semiannual seminars focusing on important issues and presenting current research findings and developments. They will also have the opportunity to develop informal, ongoing dialogue with the faculty and staff about their work on the problems of the transportation sector at large. The program will remain open to the development of new activities as the program matures -- the development of exchange programs between industry and MIT, for instance, or jointly sponsored seminars on subjects of special interest.

Solicitation of charter members is currently under way. The fee is $15,000 a year, with a minimum commitment of three years. Membership is not limited as to number of participants or the nature of their organization, but it is anticipated that by 1985 the membership will stabilize at 30 to 50 members. An inaugural meeting of charter members is scheduled for later in 1981.

Other Activities

The Center also was involved in a variety of continuing and one-time activities during the 1980-81 year. Included was the CTS Luncheon Seminar Series which brought a total of 23 guest lecturers to MIT during the fall and spring semesters; continued work on the MIT Press series on transportation; distribution of a quarterly newsletter, reports, and monographs; and a special seminar regarding rail transportation in the region (served by Conrail) for the Chairman of the United States Railway Association and his staff.

Finally, a faculty retreat was held at MIT's Endicott House in June and involved more than 40 faculty and staff, along with six students from the master's program.

The morning session was spent in intensive discussion concerning the intentions and fundamental assumptions underlying the master's program. In the afternoon, the assembly split into workshops to consider the Center's activities in two particular arenas -- transportation management and private-sector activities, and transportation issues in developing countries. The intention was to discuss the issues and obtain the faculty's assessment of the Center's efforts in education, research, and communications. Additionally, the objective was to receive the widest possible range of inputs regarding the future directions for the Center. The principal points raised at the meeting will be considered carefully as the Executive Committee convenes in the fall to chart future activities for the Center.
Innovation Center

This past year, the eighth year of operation for the Innovation Center, has been a year of transition. Program emphasis and support has been in the process of shifting from government-funded work to a much stronger involvement with the industrial sector. The background efforts throughout this transition phase have been directed toward the establishment of a stronger, more stable Innovation Center research and teaching program.

The Center offers two classroom subjects in its educational program: a subject on invention and a subject on entrepreneurship. The latter subject is an Engineering School-wide Elective subject. In addition, the Center's activity includes graduate and undergraduate thesis research, special project work, and UROP projects for students. Approximately 85 students participated on all of these activities, under the guidance of nine faculty members from various engineering departments. In addition, a visiting scholar has been involved in the Center's program.

Major tasks for the Department of Energy and the National Bureau of Standards were completed during this year. This work included development of an invention evaluation methodology which is presently the topic of a textbook nearing completion. Other work for these agencies included efforts on commercialization of energy-related inventions, investigation of human resource development for the energy innovation area, and analysis of various energy-related technologies with regard to potential for future innovation effort.

The Industry/Innovation Center Cooperative Program, mentioned in the first paragraph above, acquired its first industrial member in February. The immediate goal is to attract about 10 participating companies, thereby creating opportunities for research and product development activity for students and faculty that will enhance the educational program offered by the School in these areas.

DAVID G. JANSSON

Laboratory for Manufacturing and Productivity

During the past year, the Laboratory for Manufacturing and Productivity has continued its impressive rate of growth. Among our new industrial sponsors are du Pont, Martin Marietta, Digital Equipment Corporation, Ingersoll-Rand Corporation, and Société Stellram Anonyme.

Two new research programs were started this past year. The first, headed by Professor Neville Hogan, will be concentrating on robotics in manufacturing. The second program is a major new effort in productivity analysis. This program, which will be sponsored by consortium of industrial firms, is addressing the problems of measuring, interpreting, and improving productivity. The emphasis will be on new analytical and conceptual techniques for interpreting productivity information at the enterprise level.

The Laboratory for Manufacturing and Productivity increased its percentage of industrial funding this year to over 60 percent of an annual research budget in the vicinity of $2 million. The continued expansion and growing reputation of the Laboratory testify to the potential for interdisciplinary, cooperative research with industry.

MICHAEL B. PACKER
The Materials Processing Center was formed within the School of Engineering in August 1979, and was officially inaugurated in February 1980. Center activities encompass all engineering materials including metals, ceramics, polymers, electronic materials, composites, superconductors, and thin films. The formation of the Center reflects the growing interest and involvement of the materials community at MIT in technological problems relating to improved ways of producing and shaping materials so that they can perform more effectively for society's use -- and with acceptable economic and social costs.

The Center provides a mechanism for the staff and faculty of the School of Engineering, as well as for others, to contribute effectively to broad materials processing problems and opportunities. It interacts with industry and government in seeking to develop, extend, and apply the scientific and technological base of materials processing, and to broaden its educational base.

The current annual research budget of the Center is approaching $3 million with approximately $800,000 from industry, and strong support from NASA and other governmental agencies. These research and other Center activities currently involve the efforts of 93 faculty and staff members, plus 130 graduate students.

Major research programs are under way in 14 separate areas of materials. These are: Semiconductor Processing Research, Welding and Joining, Powder Processing/Rapid Solidification, Materials Systems, Ceramic Processing and Engineering Research, Electroprocessing, Polymer Processing, Mathematical and Physical Modeling, Corrosion Research, Mechanical Properties and Metal Forming, Composites and Non-Destructive Evaluation, Solidification Processing, Computer-Aided Processing, and Chemical Metallurgy. Research efforts in these areas over the past year are outlined in the first Annual Report of the Materials Processing Center.*

Important expansions of our effort during the past year have taken place in a number of areas. One that is particularly worthy of note is rapid solidification, with a large number of faculty participating, including Professors Morris Cohen, Nicholas Grant, and Gregory Yurek. Another is electroprocessing under the direction of Professor Donald Sadoway and the electronic materials crystal growth program of Professor August Witt. Other areas that have seen special growth include Professor Joel Clark's materials systems, Professor Thomas Eagar's welding activities, and the ceramic processing work of Professor Harvey Bowen and others.

The Materials Processing Center at MIT represents an important new direction for materials science and engineering, and we are pleased that our Center is already serving as a model for development of similar centers in research facilities and academic institutions.

MERTON C. FLEMINGS

School of Humanities and Social Science

The past year was dominated by the news from Washington of cuts and impending cuts in funding for the arts, humanities and social sciences. The heavy cuts proposed by the Reagan Administration were aimed more specifically at the social sciences and might well have had the effect of depriving social scientists of a very large proportion of their research funding and of depriving their students of the small number of remaining social-science NSF fellowships. Congress proved to be more resistant to these cuts than might have been expected, however, and at the time of this writing it seems likely that the arts and humanities will escape the most drastic of the proposed cuts. The level of social science funding is still uncertain.

The proposed cuts in government funding were a natural consequence of the rapid expansion that had taken place in the last few years in certain areas. It has not always been clear that the policies of the responsible Federal agencies have been wise ones, and whenever there is a squeeze it is natural to question past priorities. Moreover, in expecting the Federal government to fund large numbers of non-academic projects of a local character in the arts and humanities, congressmen tended to lose sight of the fact that money was being committed to projects that were often extremely ephemeral. Our task in the next few years will be to help the Federal government work out better longer-term priorities.

This is particularly necessary because we need to begin now to plan for the 1990s when there will be many faculty retirements and when there are likely to be substantially larger numbers of students of college age. We are likely to find, particularly in the humanities and social sciences, that there is a serious shortage of first-rate faculty members because the best students have been diverted by economic pressures into other employment. It commonly takes at least eight or nine years (four years in college, four or five years in graduate school) to produce a good Ph.D. We should begin now to examine the gaps that will open up in the 1990s and plan to fill them.

Nearer home there have been a number of significant changes in the School. Professor Donald L. M. Blackmer, who has served with distinction as Associate Dean since 1973 in a wide variety of roles -- including those of director of Modern Languages and Director of the Program in Science, Technology, and Society -- will go on leave in fall 1981 and will return in the spring to his old department, Political Science, as Head of that Department. Professor Peter H. Smith who was chosen last year to be the new Head of the Department of Humanities and Associate Dean for Humanities Programs took up his new position in the fall and, as expected, found the post a challenging and sometimes frustrating one. But Professor Smith will be able to draw on the increasing sense of professionalism that has distinguished the department in the last few years in helping him to raise outside funds, particularly to help strengthen research.

There will be two other changes in the leadership of the School in the coming year: Professor Carl Kaysen will become Director of the Program in Science, Technology, and Society in July and Professor Alan A. Altshuler will return to full-time teaching and research after three-and-a-half years as Head of the Department of Political Science in January. Professor Kaysen will have the task of moving the STS program to its new building late in the fall as well as of strengthening its connections with the Schools of Engineering and Science. Professor Altshuler will continue with his large-scale transportation project.

A number of changes will be made possible by the move of the STS program to Building E51. The headquarters of the Department of Linguistics and Philosophy will move to the top floor of Building 20D and the offices of the faculty and research staff of the Department and Center for Cognitive Science will be consolidated. This move will enable the Anthropology/Archaeology Program of the Department of Humanities to move into adjoining space on the second floor of Building 20. There they will for the first time be able to develop an undergraduate laboratory.
The Committee on Educational Policy will continue to review the General Institute Requirements for the S.B. degree in the coming year, among them the Humanities, Arts, and Social Sciences Requirement. Already there is welcome agreement that a writing requirement should be instituted. It is also to be hoped that there will be a clarification of the meaning of the Distribution Requirement, which has proved very hard to administer in its present form. In general, as I have suggested in previous reports, the Humanities, Arts, and Social Sciences Requirement appears to be working well. It is sufficiently flexible to allow venturesome students to strike out on their own, when they are well prepared to do so, as when they develop special concentrations. It enables students to pursue those studies which most interest them in at least minimal depth. And it does seem to provide some of those wider perspectives that are so valuable to students in later life. Few students have probably found their lives much changed because the Requirement forced them to study subjects in which they were not interested, but a significant number of students have found that the Requirement enabled them to enrich their lives by studying subjects for which otherwise there would be no time.

HAROLD J. HANHAM
### TABLE I

Enrollment in Distribution Subjects: 1980-81

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<th>Field</th>
<th># of Subjects</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4 &amp; 5</th>
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<th>Wellesley</th>
<th>Harvard</th>
<th>GRAND TOTAL</th>
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Enrollment data are taken from the Registrar's fifth week report.
### Table II

Enrollment in Humanities, Arts and Social Sciences Elective Subjects: 1980-81

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<th>Year 3</th>
<th>Year 4 &amp; 5 Graduate</th>
<th>Total MIT</th>
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<th>Harvard</th>
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The figures include all subjects listed in the Catalogue as routinely eligible toward the Institute Requirement, and in which students actually enrolled. Other subjects approved by petition have not been counted. Data are taken from the Registrar's fifth week report.
### TABLE III

Fields of Concentration Selected

Under the Humanities, Arts, and Social Science Requirement

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### TABLE IV

**Undergraduate Majors in the School of Humanities and Social Science***

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* As registered in the second term of academic year 1969-70 to 1980-81 (omitting Freshmen and Undesignated Sophomores). Data taken from the Registrar's fifth-week report.

### TABLE V

**Graduate Students in the School of Humanities and Social Science***

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<th>Psychology</th>
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<td>66***</td>
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</table>

** As registered in the second term of academic year 1969-70 to 1980-81 (including special graduate students). Data taken from the Registrar's fifth-week report.

*** Includes students in linguistics.
The size of the program in Economics, both undergraduate and graduate, continued at about
the same level as in the past several years, with some modest shrinkage in the graduate pro-
gram because of problems in fellowship support and some modest expansion of the undergraduate
program in numbers of non-majors.

Faculty research has covered a wide range of subjects. Major published projects included
Professor Rudiger Dornbusch’s *Open Economy Macroeconomics* and, with Professor Stanley
Fischer, the second edition of their popular text, *Macroeconomics; Rational Expectations and
Economic Policy* edited by Professor Fischer; Professor Ann F. Friedlaender’s *Freight Trans-
portation Regulation* (with former student Richard Spady) and the seventh edition (with
John F. Due) of the widely used text, *Government Finance; Structural Analysis of Discrete
Data with Econometric Applications* edited by Professor Daniel L. McFadden (with former
student Charles F. Manski); the Geary Lectures that Professor Robert M. Solow gave at the
University of Dublin, *The Story of Social Experiment and Some Reflections*; Professor Lance J.
Taylor’s *Models of Growth and Distribution in Brazil* (with former student Eliana Cardoso and
others); Professor Peter Temin’s *Taking Your Medicine: Drug Regulation in the United States*;
and Professor Lester C. Thurow’s *The Zero-Sum Society*.

The Department took the responsibility for organizing a session on "The Economy of the '80s"
in a symposium of the Industrial Liaison Program in honor of retiring President Jerome B.
Weisner entitled *The Decades Ahead: An MIT Perspective*. The participants were Professors
E. Cary Brown, Dornbusch, Fischer, Franco Modigliani, Paul A. Samuelson, Solow, and
Thurow.

Honors and awards to faculty this year included the election of Professor Peter A. Diamond
to the Council of the Econometric Society; a two-year Sloan Research Fellowship to Professor
Henry S. Farber; the election of Professor Fischer as Fellow in the American Academy of Arts
and Sciences; the award of a Guggenheim Fellowship to Professor Franklin M. Fisher; the
selection of Professor Michael J. Piore to be the Mitsui Professor of Problems in Contemporary
Technology; the election of Professor McFadden as Fellow of the National Academy of Science
and his selection as the outstanding Departmental teacher by the Graduate Economics Associ-
ation; the awards of a Doctor of Economics, Honoris Causa, to Professor Samuelson by the
Catholic University of Peru, and an L.L.D. to Professor Solow by Wesleyan College.

There were several changes in faculty this year. Professor Dornbusch was on leave in Brazil
in the fall term, Professor Piore in the spring term, and for the year Professor Eric S. Maskin
was at Cambridge University, and Professor Thomas J. Teisburg worked in industry. To
fill some of these gaps, Professor Reuben Gronau visited for the year from Hebrew University,
and Professor Paul R. Krugman has come jointly to our Department and the Sloan School.
Charles P. Kindleberger, Ford Professor Emeritus of International Economics, who has served
half-time as Senior Lecturer for the past five years, retires at the end of this year. His
lively mind, his active stimulation of students, and his forceful and imaginative presence will
be greatly missed.

Finally, the Department’s major concern is and has been the financing of fellowship support
for our Ph.D. candidates. Over the years both in annual reports and reports to Visiting
Committees the Department has pointed with pride as well as with concern to our success in
attracting students with National Science Foundation (NSF) Fellowships: pride, because one-
third to one-half of national NSF Fellows in economics elect to study in our Department;
concern, because (among other things) the program was politically vulnerable. While the Reagan
Administration has recommended the termination of the NSF Fellowship program, Congress has
not completely accepted that view. The present budgetary conflict between the two Houses
and the Administration makes the final outcome uncertain. Awards were made for this year
and half will become our students. Nevertheless, we are taking steps, within the Institute
guidelines, to offset a portion of the substantial and crippling losses that our graduate program would suffer.

E. CARY BROWN

Department of Humanities

The arrival of a new department head in July 1980 prompted curiosity and concern about longstanding issues of governance: the relative emphasis on "sectional autonomy" and departmental unity," the relationship between tenured and untenured faculty (within and between sections), the connection between administrative leadership and professorial responsibility. There were some trials, and not a few errors, but the outlines of a consensus began to emerge by the end of the year. The Department of Humanities will continue to consist of six sections, each coequal in juridical status, each an integral part of the larger developmental unit: Anthropology/Archaeology, Foreign Languages and Literatures, History, Literature, Music, and the Writing Program. Notwithstanding their differences, they share a common sense of intellectual and academic purpose, a commitment deliberately shaped to meet the special needs and characteristics of the MIT community.

These goals find expression in a new departmental brochure, published in the spring of 1981. "It is the mission of humanities," the statement begins,

> to explore and to enrich creative expressions of the human imagination. Humanistic inquiry reveals the broad varieties of cultural experience, it traces change and continuity through time, it celebrates both the inspiration and articulation of ideas. Its sources come from elements of communication -- the written word, the musical phrase, the stroke of a brush -- and its subjects span the total range of human sensibilities: emotion, attitude, belief, myth, fantasy. Ultimately, the humanities confront timeless questions of ethics and values, they probe moral complexities, they affirm the uniqueness of individuals while underscoring the commonalities of humankind.

Humanists do not produce definitive answers. Their method frequently relies on allusion, metaphor, and interpretation, rather than experiment and declaration. This inherent uncertainty not only prompts humanists to ponder, perhaps more explicitly than scholars in other fields, the viability of alternative explanations; it also leads them to insist upon the need for systematic doubt, analytical rigor, and logical precision.

In keeping with this commitment faculty members throughout the Department strive for the highest level of professional accomplishment, and through teaching they bring their knowledge and insight to MIT undergraduates. Working within their fields of specialization, they also take advantage of special opportunities for collegial collaboration, thus developing multidisciplinary perspectives on themes of humanistic inquiry.

As an example of such activity, members of the Department faculty established a half-dozen research workshops in 1980-81. Topics covered a broad span, from "Film as a Literary Genre" to "Ethnic Identity in Latin America" to "Women, Class, Race, and Culture." One of the symposia, coordinated by Professor Robert I. Rotberg, culminated in a two-day conference at Endicott House on "History and Psychobiography: Narcissism and the Ego Ideal."

To further stimulate faculty research, the Department created a clearinghouse for information on grants, fellowships, and other funding sources. Preliminary steps were also taken toward the articulation of a long-run development plan, with primary emphasis on the expansion of opportunities and resources for faculty research.

In addition, the Department began to consider aspects of its curriculum. One ad hoc study group explored the possibilities for offerings in women's studies at MIT; another examined the program in drama. A broadly representative Curriculum Committee will be established in 1981-82 to take a comprehensive view of Department programs and offerings.
After more than a year of inquiry, yet another ad hoc committee submitted a probing report on affirmative action. The topic is one of major importance, for the Department as well as for the Institute, and it will be a subject for extended collective deliberations.

Through it all, as section reports indicate, the faculty continued to play active professional roles. To take just one example from each section: Professor James Howe (Anthropology/Archaeology) coauthored a Cultural Survival Special Report entitled Indian Peoples of Paraguay, Their Plight and Their Prospects; Professor Elizabeth Garrels (Foreign Languages and Literatures) won a prestigious grant from the Social Science Research Council to proceed with her work on the concept of paternalism in Spanish American literature; Professor Pauline Maier (History) has received numerous accolades for her latest book, The Old Revolutionaries, a study of the lifelong careers and attitudes of those who led the American colonists toward independence; Professor Cynthia Griffin Wolff (Literature) served on one prize committee in American literature, was asked to serve on another for the Modern Language Association, and produced an article on Emily Dickinson for the Harvard Magazine; Professor John Harbison (Music) won the 1980 Friedheim Award for a piano concerto; and, in response to a proposal by Professor Rae Goodell and her associates (Writing), there was established the DeWitt Wallace/Reader's Digest Endowment for Science Writing.

In a frantic attempt to keep up with the pace, I myself continued to serve as president of the Latin American Studies Association, a national organization, and to sit on evaluation committees for the Tinker Foundation and the Inter-American Foundation. In December 1980 I presented a paper at the annual meeting of the American Historical Association, and this spring an article on "Political History in the 1980s" appeared in a special issue of the Journal of Interdisciplinary History. I also had the special pleasure of addressing the Feria Internacional del Libro (International Book Fair) in Mexico City on the occasion of the publication of the Spanish-language edition of my book on Mexican politics. Its title in English is Labyrinths of Power.

PETER H. SMITH

ANTHROPOLOGY/ARCHAEOLOGY PROGRAM

Professor Martin Diskin completed his third and last year as chair of the Anthropology/Archaeology Program. He also served on the HASS Committee for the second year. He was chairman and affirmative action officer of a joint Science, Technology, and Society (STS) Program and Humanities Department search committee for a cultural anthropologist specializing in the study of science or technology. He participated in a three-person committee that studied minority recruitment and hiring within the Department of Humanities which culminated in a 16-page report distributed to all colleagues in Humanities. Professor Diskin also was appointed a member of the Joint Committee on Latin American Studies of the Social Science Research Council. He participated in the Fifth World Conference on Rural Sociology in Mexico City, August 1980, and helped plan and participated in an international conference held at Endicott House on Spanish-Indian Contacts in Southern Mesoamerica, October 1980. His article entitled "The Peasant Family Archive -- Ethnohistory of the Present," has been accepted for publication by Ethnohistory.

Professor James Howe has been appointed as the new head of the Anthropology/Archaeology Program, to replace Professor Diskin. During 1980-81 Professor Howe served on the joint STS/Humanities search committee for a new cultural anthropologist, was concentration advisor for Anthropology/Archaeology, supervised an undergraduate thesis by William Zajak, and was a member of the steering committee for American Studies. A Cultural Survival Special Report (122 pages) co-authored with David Maybury-Lewis, called Indian Peoples of Paraguay, Their Plight and Their Prospects, was published in the fall of 1980. A paper by Professor Howe entitled "Fox Hunting as Ritual" appeared in the spring issue of the American Ethnologist; another written with Lawrence Hirschfeld, "The Star Girls' Descent: A Myth about Men, Women, Matrilocality, and Singing," appears in the July-August issue of the Journal of American Folklore; and a paper on the Kuna kinship system has been accepted for publication in an edited volume on the natural and social environments of Panama.
Professor Jean E. Jackson served on the National Endowment for the Humanities (NEH) Medial Panel in September 1980, which reviewed 56 proposals. She served on the Corporation Joint Advisory Committee, the Committee on Curricula, and the Experimental Study Group Supervisory Committee. She is a member of the advisory committee for Women in Development, a joint consortium between MIT's Center for International Studies and the Harvard Institute in International Development which sponsored an all-day workshop on "Women, Work, and Public Policy," at MIT in February 1981. In the spring, with the help of other interested members of the Humanities Department, she began to explore possibilities for Women's Studies at MIT. She delivered an invited paper entitled "Baré Concepts of Self and Other" at the American Anthropological Association meeting in Washington, DC, in December 1980. Professor Jackson is completing a major revision of her manuscript "The Fish-People: Linguistic Exogamy and Tukanoan Identity in the Northwest Amazon," which has been accepted for publication by Cambridge University Press.

Professor Heather N. Lechtman continued as coeditor of Art and Archaeology Technical Abstracts and as vice president of the Institute of Andean Research, NYC. She served as a member of MIT's Committee on the Visual Arts and on the Arts Advisory Group. Much of her time was spent in administering the Center for Materials Research in Archaeology and Ethnology (CMRAE), of which she is director. She initiated and helped organize a lecture series, "New Perspectives in Ceramic Archaeology and Physical Anthropology," which was held at MIT from December 1980 through February 1981. Professor Lechtman was also the chairwoman of a search committee for a new appointment in the Anthropology/Archaeology Program and in CMRAE. Professor Lechtman published a chapter entitled "The Central Andes -- Metallurgy without Iron," in The Coming of the Age of Iron, Yale University Press and a book review of Ars Orientalis 11, the Memorial Volume to Rutherford J. Gettens. She received a grant from the Tinker Foundation for preparation of the manuscript of the second volume Runakunap Kawsaynikupaq Rurasqankunaqa (La tecnología en el mundo andino) to be published by the press of the Universidad Nacional Autónoma de México. She received another grant from Asarco, Inc. in support of her research on copper-arsenic and copper-tin bronzes from pre-columbian South America. In February 1981 Professor Lechtman gave an invited paper on "Copper-arsenic Bronzes from the North Coast of Peru," at the New York Academy of Sciences Conference on the Research Potential of Anthropological Museum Collections which will be published in the Annals of the Academy. An article about Professor Lechtman, describing her early research in neutron autoradiography of oil paintings and the use of the technique to study the works of Rembrandt, appeared in the April 1981 issue of Technology Review. A companion piece described Professor Lechtman's activities at MIT, particularly her role as director of CMRAE.

Professor Arthur Steinberg spent the spring term on a leave of absence without pay, during which he was in England studying tempera and oil media in Renaissance painting. During the fall term he was senior thesis advisor to Amelia Phillips and supervised a project on Reduction-Fired Pottery by J. R. Kasper. He also served on the program committees of CMRAE and the Archaeological Institute of America.

Professor Wilma E. Wetterstrom was the main force in planning and developing the forthcoming Anthropology/Archaeology laboratory to be housed in Building 20. She has worked out the curriculum for a new subject which will use the laboratory as its principal research facility. Professor Wetterstrom also helped organize the lecture series "New Perspectives in Ceramic Archaeology and Physical Anthropology" with Professor Lechtman. She also served with Professor Lechtman on the search committee for the joint appointment in the Anthropology/Archaeology Program and CMRAE. During the summer of 1980 Professor Wetterstrom engaged in archaeological field research at two Predynastic sites in Upper Egypt. She supervised the recovery of archaeological plant remains which she is now analyzing in her laboratory at MIT. In October Professors Wetterstrom and Lawrence Kaplan (University of Massachusetts at Boston) submitted a grant proposal to the National Endowment for the Humanities (NEH) to support a collaborative research project on phytoliths, plant silica bodies, from archaeological sites. She had two articles published within the last year, one of which she coauthored with several members of the excavation team from her summer field work entitled "Agricultural Developments in the Nagada Region during the Predynastic Period," which appeared in the fall 1980 issue of Nyame Akuma. The other, "Predynastic Agriculture in Upper Egypt: A Note on Palaeoethnobotanical Studies in the Nagada-Khattara Region," was published in the Bulletin de L'Association Internationale Pour L'Etude de la Préhistoire Egyptienne in November 1980.
The Anthropology/Archaeology Program hired two part-time visiting instructors: Jeffrey Altschul taught 21.552 Origins of Civilization -- Mesoamerica in the fall and Martha Prickett taught one section of 21.503 Approaches to Archaeology as well as 21.553 Origins of Civilization -- Middle East. The Program also hired Visiting Lecturer Rosemary Sharp to lead one section of 21.50 Introduction to Anthropology during the fall term.

Throughout the year two searches were conducted: one for a joint position as a cultural anthropologist (with STS) and the other also for a joint position as a ceramic/physical archeologist (with CMRAE). The committees are pleased to have selected Professor Sharon Traweek (Stanford University) as the new cultural anthropologist and Professor Suzanne DeAtley (Smithsonian Institution) to fill the latter position.

The growth of the Anthropology/Archaeology Program is exemplified by the hiring of part-time instructors, the development of new laboratory facilities, and the creation of two new positions within the Program.

MARTIN DISKIN

FOREIGN LANGUAGES AND LITERATURES SECTION

During the past year the faculty and staff in Foreign Languages and Literatures have worked extensively in three major areas: evaluation and elaboration of the curriculum, the expansion of activities bringing together scholars and students from within and outside the Institute, and the establishment of a leadership position in our fields through scholarly activities.

Curriculum

A Foreign Languages and Literatures Curriculum Committee, made up of junior and senior faculty members, was formed for purposes of examining and shaping the Section's curriculum. During the academic year, the Committee addressed enrollment problems, issues of overlap between subjects offered both within and outside the Section, future direction and innovations desired for the curriculum, and teaching methodology.

The addition of several courses in areas not previously covered by the Section's curriculum has contributed to the ongoing development of the Section. New courses such as An Introduction to Latin American Culture and the Culture of the Weimar Republic have expanded the cultural component of our offerings, while other new courses, including French Lyricism: From Literary Text to Opera, Heinrich Heine, The Don Juan Legend, and Sex Roles: Europe and Latin America, present literary genres and themes which have not previously been explored.

A series of pedagogy lectures by Section faculty and staff members who are specialists in teaching methodology were held as a means of strengthening the teaching capabilities of our staff and faculty. Faculty and staff of other Sections of the Department and from other institutions in the Boston area were invited to attend the series.

Professor Suzanne Flynn of Cornell University was appointed as a result of a nationwide search for a new coordinator of our program in English as a Foreign Language. Professor Flynn's research in second language acquisition as well as her extensive teaching and administrative experience will contribute to the functioning of this program which provides essential English language training to MIT's foreign students and scholars. She will be working with departments at MIT to ensure that our program is meeting the needs of graduate students as effectively as possible.

Sponsored Activities

The 35 activities sponsored by the Section during the past year drew hundreds of people from within and outside the Institute for the exchange of ideas about topics related to foreign...
literature, applied linguistics, film, and international politics. These events represented an increase of 50 percent over last year and helped extend knowledge of our program, faculty, and interests throughout the community. In the past year, there was also a marked increase in the number of events organized by the Section in cooperation with other divisions at MIT as well as with institutions and organizations outside the Institute.

Perhaps the best attended event was the New French Film Festival organized by Professor Edward B. Turk in cooperation with the French Embassy. The festival brought approximately 1,000 people to MIT to view and discuss French films not previously released in this country with French filmmakers, including Marcel Carné and Patricia Moraz.

A conference on El Salvador, cosponsored by Foreign Languages and Literatures and the Anthropology/Archaeology Program brought students, faculty, and other interested people in the Boston area to MIT to discuss events in Central America. Additional activities cosponsored with other programs, sections, and departments at MIT included lectures by a Mapuche Indian leader (with Anthropology/Archaeology), La Calle Editor Jaime Sartorius (with the History Section) and Professor Stephen Krashen (with the Department of Linguistics and Philosophy and the Division for Study and Research in Education), as well as a series of IAP lectures on "Understanding Americans" (with the History Section).

Cooperation between the Section and outside schools and institutions was enhanced by a number of activities. A French Language Immersion Weekend, organized by Lecturer Giliberte Furstenberg and supported by the Section, brought French students from regional high schools and colleges to MIT for a weekend of intensive language learning in June. Professor Margery Resnick played a key role in the planning of the week-long Quevedo Symposium jointly sponsored by the Spanish Consulate and major Boston universities. Instructor Edith Waldstein took part in and was on the organizing committee of a symposium held at Wellesley College titled "Breaking the Sequence' Women, Literature and the Future: An International Symposium on Women Writers" for which Section Administrative Assistant June P. Al-Khatib did promotional artwork.

Theatre became a main area of focus for activities outside the classroom over the past year. The Section worked with Harvard University and the Consortium of Foreign Language Departments in the planning of a performance at MIT of Godot's play En Attendant Godot (Waiting for Godot) by a French cast. During IAP, Professor Michael Geisler, Instructor Gladys Varona-Lacey, and Lecturer Douglas Morgenstern worked with students on plays in German and Spanish that were subsequently performed for large audiences at MIT. The Spanish plays were performed at Tufts University, and one, Los Esclavos, was broadcast on Channel 4's Spanish program "Nosotros." Parlons Francaise, an adaptation of works by Eugene Ionesco, was performed at MIT by a theatre troupe made up of Tufts University students and professional actors from Paris.

A series of faculty lectures, designed to share the scholarly expertise of the Section's faculty with professional colleagues and students both at MIT and in the Boston area, was given by Professors Krystyna Pomorska, Robert E. Jones, Resnick, Turk, and Senior Lecturer Claire Kramsch.

The faculty and staff in Foreign Languages and Literatures helped the French, German, Russian, and Spanish language houses offer activities that extended language learning beyond the classroom.

Faculty and Staff

Section faculty and staff have served the Department and the Institute in a variety of ways. Professor Catherine V. Chvany participated in the Independent Activities Period Committee; Professor James W. Harris served as a graduate registration officer for the Department of Linguistics and Philosophy; Professor Frederick Hodgson took part in the reading of freshman applications in his role as a member of the MIT Admissions Committee; Professor Jones was a member of the MIT Committee on Foreign Scholarships; Senior Lecturer Kramsch was one of the principal contributors to the Humanities Department's Minority Recruitment Report which is being used by other departments as a model in the area of minority hiring; Professor Resnick served on the Committee on Educational Policy, the Committee on Student Affairs.
Department of Humanities

the Advisory Committee on Women Students' Interest, and as Housemaster of McCormick Hall; and Professor Turk served on the Humanities, Arts, and Social Sciences Committee, and initiated the MIT/Ecole Normale Superieure Student Exchange Program that will be put into effect during the 1981-82 academic year. Seven faculty members also served as freshman advisors over the past year.

Several members of the Section served in leadership capacities in scholarly organizations this year. Professor Resnick was president of MIT's Phi Beta Kappa Fraternity and executive director of the Boston Consortium of Foreign Language Departments. Professor Chvany continued her duties as vice president of the American Association of Teachers of Slavic and Eastern European Languages. Lecturer Katherine Paszkolovits was elected president of the Massachusetts Chapter of the American Association of Teachers of German. Lecturer Abelle Mason served on the Board of Directors of the Massachusetts Association of Teachers of Speakers of Other Languages.

A number of individuals in the Section were invited to chair colloquia, speak at other universities, and to deliver papers at national and international meetings during the 1980-81 school year. Details of these activities are included in the archival version of this report.

Publications

During the past year members of the Section published widely in the fields of literature, linguistics, language pedagogy, and film. In addition to essays and book reviews accepted for future publication, numerous articles by faculty and staff appeared. The following articles in the field of literature provide a sampling of the variety of literary research pursued by members of the Section: Professor Julia Aliassandratos's "The Structure of the Funeral Oration in Jon Chrysostom's Eulogy of Meletius;" Professor Kathryn Crecelius's "Fictional History in Mérimées Chronique du regne de Charles IX;" Professor David Dollenmayer's study "An Urban Montage and its Significance in Döblin's Berlin Alexanderplatz;" Professor Jones's article on Lenormand in the Columbia Dictionary of Modern European Fiction; Professor Pomorska's "On Parodic Parallelism in Gogol's Prose;" and Professor Turk's "Comic Game Play in Rotrou's La Seour." Professor Turk also published two film studies, "Balm of Giliat" and "Fagnot's Marseilles Trilogy," in American Film. An International Bibliography of Women Writers in Translation edited by Professors Resnick and Isabelle de Courtivron is scheduled for publication in summer 1981.

Studies produced by those in the Section whose primary scholarly interest is linguistics included: Professor Chvany's coauthored "Morphosyntax: Forms and Meaning Through a Syntactic Prism" which is the lead article in Morphosyntax in Slavic, which she coedited with R. D. Brecht; and Professor Harris's "La estructura fonica de la lengua castellana."

Grants

A number of faculty members have received grants. Professors Dollenmayer, Frederick Hodgson, Crecelius, and Elizabeth Garrels have all been awarded Old Dominion Fellowships. Lecturer Paszkolovits and Professor Turk have received summer stipends from the National Endowment for the Humanities. Lecturer Paszkolovits was also granted a research stipend by the Goethe Institute. Professor Garrels was awarded a grant by the Joint Committee on Latin America of the American Council of Learned Societies and Social Sciences Research Council. Professor Crecelius was also awarded a Carmagio Foundation grant. Senior Lecturer Kramsch received a grant for a two-week study trip in Germany from the Federal Republic of Germany.

Student Awards

Spanish student Ronald C. Tyler, who directed and acted in the Spanish plays performed during IAP under the auspices of the Foreign Languages and Literatures Section, received the Weisner Award for achievement in the performing arts at MIT. The language houses were nominated for the Irwin Sizer Award for service to the MIT Community.

MARGERY RESNICK
HISTORY SECTION

Perhaps the most important accomplishments of the Section as a whole during the year 1980-81 lay in the area of faculty and curriculum development. In the fall term Peter C. Perdue began teaching East Asian history at the Institute, and in the spring the Section conducted an extensive search in Middle Eastern history, culminating in the appointment of Professor Philip Khoury. Professor Peter H. Smith, who is completing his first year as Head of the Department of Humanities, plans to begin teaching Latin American history next year. With the pending appointment of a Middle Eastern historian, the Section will have added to its curriculum in two years subjects in the history of three major areas of the world, expanding significantly the educational opportunities open to MIT undergraduates.

The year 1980-81 was also distinguished by the presence of Professor Michael Les Benedict as a visiting associate professor during the spring term. Professor Benedict, a well-known authority on the history of reconstruction, offered a popular subject on the American Civil War and Reconstruction, and assumed responsibility for the second half of the basic survey of United States history, 21.391. Gary Kornblith, a part-time instructor in American history for the year, also supplemented the Section's offerings in American History, taking on subjects on the Development of the Republic, 1790-1850, and the United States since World War II. Next year Professor Benedict will teach in Japan under the Fulbright program, and Mr. Kornblith will join the faculty of Oberlin College. Their places will be taken by two new temporary appointments in American history: Professor Elizabeth Pleck, of the Wellesley College Center for Research on Women, will offer a subject on women's history in the spring term, and Professor Ellen Fitzpatrick will collaborate with Professor Alan D. Brinkley in teaching 21.390 American History to 1865 in the fall, and will offer a subject on the Progressive Era in the spring. This series of temporary appointments reflects in part a continuing need for another American historian on the Section's staff, but also provides an opportunity to experiment, offering new subjects such as women's history to test student interest. While the temporary appointments will significantly enrich our offerings in American history during 1980-81 and 1981-82, it is the Section's hope that the experience gained from those appointments will be of considerable use in defining possible future positions.

The Section also took positive steps during the past year to comply with the administration's directive that it, with other academic units within the Institute, begin a process of "continual search" for well-qualified minority scholars. Early in 1981 some 25 letters were sent out to the chairpersons of leading graduate departments of history or Afro-American studies and to other persons likely to know promising or accomplished minority historians. Nominations were solicited of appropriate people who might be interested in coming to MIT as visiting or regular faculty members, or perhaps as speakers, regardless of rank or specialty, though the Section's needs in American and Islamic history were specifically mentioned. The people nominated were then contacted separately; and as a result nine minority candidates put themselves forward for positions at MIT. The search committee -- consisting of Professors Arthur D. Kaledin, Pauline Maier, and Merritt Roe Smith -- scrutinized their dossiers, and decided to consider first those whose specialties fit most closely those of the Section in American history. (The one candidate in Islamic history who came forward as a result of the "continual search" was referred to the search committee for that position.) A lunch meeting was arranged in April with Professor Nell Painter of the University of North Carolina, Chapel Hill, to discuss her professional plans and MIT's needs; and in May Professor Armstead Robinson of the University of Virginia, a historian of Reconstruction, the South, and of Afro-Americans, met with members of the section and offered an open talk on Why did the South Lose the Civil War? The committee has recommended no appointment at this time, but feels confident, given its experience this year, that there are well-qualified black candidates for positions in history at MIT, and that it has made significant progress in locating such persons and in establishing the kind of contacts that will prove helpful in carrying on its search for minority candidates in the future. With time, there is reason to hope that a distinguished appointment will prove possible.

The Section's activities also included the organization by Professor Bruce Mazlish and Lecturer Perdue of a History Faculty Workshop on "Women and Men in History" that met in four sessions between February and April 1981. Professor Richard Stites of the Woodrow Wilson Center in Washington, DC, opened the series with a talk on "Women in the Russian Revolution;" Professor Marilyn Young of New York University followed with a presentation on "Women in the Chinese Revolution;" then Professor Louise Tilley of the University of Michigan talked on "Women and
Industrialization in Europe." Kathleen Dalton of Phillips Academy and Tony Rotundo, a doctoral candidate at Brandeis University, concluded the Workshop with a discussion of "Sex Roles and Historical Change in American History." It should be noted, too, that in November the Section sponsored a lecture on blacks in the American Revolution by Professor Peter H. Wood of Duke University, author of Black Majority, a prize-winning book on colonial South Carolina.

Section members were fully active in the committee life of the Institute and the Department: they served as undergraduate thesis and freshman advisors and on several faculty review committees for other sections within the Department as well as their own; on the Inauguration Committee, the Committee on International Institutional Commitments, and the Committee on Discipline. Professor Arthur Kaledin was acting director of Course XXI during the spring term.

Publications

MIT historians have remained active in the lives of their professions, making a noteworthy contribution above all to the publication of scholarly journals. Professor Robert I. Rotberg continues to edit the Journal of Interdisciplinary History, which is published out of Building 14. Other members of the Section are on the editorial boards of The Business History Review, Reviews in American History, Wissenschaftsforschung, Strategy and Policy, the Journal of Family History, and The Psychohistory Review. Professor Mazlish is also a vice president of the International Society of Political Psychology; Professor Maier is on the executive board of the Organization of American Historians; and Professor William B. Watson is chairman of the Board of Governors of the Abraham Lincoln Brigade Archive.


Professor Brinkley was on leave during 1980-81, while he held an Old Dominion Fellowship and a grant from the American Council of Learned Societies. I will be on sabbatical leave during the fall of 1981; and Professor David B. Ralston has consented to serve as acting Section Chair in my absence.

PAULINE MAIER

LITERATURE SECTION

Many of the most exciting activities within the Literature Section this past year have grown out of the successes of the tiered curriculum, developed over the past several years and first put into place in 1979-80. This three-part curriculum divides the discipline into three levels of difficulty, each representing a different degree of specialization: introductory courses (genre, historical survey, and thematic) which have no prerequisites and are aimed at elementary college-level instruction, middle-group courses which have a prerequisite (these are comparable to the courses that an English "major" might take at one of the Ivy League universities), and advanced seminars. The seminars, which offer faculty the opportunity to teach their own current research, give students a chance to have in the Humanities something they have hitherto had most often in their science courses -- work which stands at the forefront of the discipline.
The success of the new curriculum can be measured in a variety of striking ways. First, we
have begun to observe that many of our students, having had an enjoyable introductory course,
continue to work within the Section at a more advanced level. Only about 50 percent of our
students are enrolled in "Humanities Distribution" subjects; the others have pursued the study
of literature because they responded favorably to the strenuous intellectual challenge they had
been offered at the introductory level. Most striking, perhaps, is the fact that virtually all
of our seminar-tier subjects were enrolled to capacity -- several enrolled at substantially over
capacity. The enrollment picture has been so clear that we feel compelled to expand our cur-
riculum at this advanced level -- both by encouraging our own faculty to offer more seminars
and by inviting faculty from neighboring disciplines, such as Writing, to teach a seminar on
the subject of their current research.

At the same time that we recognize the need to strengthen this advanced level of our curriculum,
we see the need to broaden and extend the introductory level. It is a fact that students who
major in some of the "hard" sciences still shy away from Humanities, feeling, perhaps, that such
study is uncongenial to their own field of interest, or that it will draw upon skills in which they
are weak, or that the "bookish" subject matter will be too foreign to the visual and audio culture
with which they feel comfortable. It is significant, for example, that film courses are consistently
well-enrolled. One's first reaction might be to assume that these courses are "easy" -- that they
have less stringent requirements than more traditional courses; but such is not the case at all.
Rather, it seems to be the case that our students have grown up in a culture where films or
television are more accessible forms of "literature" than the written word. Hence, many MIT
students want to begin their literary study with these familiar modes. However, our experience
as teachers is that most students, once having begun with a form that is, at least in part, visual,
are subsequently emboldened to attempt more "traditional" literary forms. Many students who
begin with a film course in the fall term go on to take a course in fiction during the spring term;
indeed, many students have moved from an introductory film course into an intermediary fiction
or poetry course.

Having observed these patterns of enrollment, we have decided to expand our film and media-
studies -- expecting to develop a fuller and more fully tiered curriculum here comparable in
some ways to that in the more traditional literary studies. We are initiating a sequence next
year in Fantasy Faction (fall term) and Science Fiction (spring term); these courses, which will
not carry Humanities Distribution credit, will be aimed at the very large number of students who
read these fictional forms for pleasure -- not knowing, perhaps, that there is an intellectually
rigorous and interesting way of approaching them. Our expectation is that at least some of the
students who enroll in these "popular fiction" courses will subsequently be stimulated into taking
more traditional literature courses.

Our two new junior appointments this year reflect the diversity just described. To expand the
staffing of our more traditional courses, we have invited Dr. William J. Paul to join the Section.
Dr. Mullaney, who did his graduate work at Stanford University, is the result of a several-year
search to bolster our Renaissance and 17th-century areas. Dr. Mullaney will add strength to our
Shakespeare offerings and to our introductory courses as well as being able to teach his own
specialty, 17th-century poetry. He has already published one substantial essay, "Lying like
Truth: Riddle, Representation, and Treason in Renaissance England," in English Literary History --
a penetratingly new study of Macbeth.

To expand the staffing of our film courses, we have invited Dr. William J. Paul to join the Section
again next year. Dr. Paul had a one-year appointment this past year to teach film, and he was
such an extraordinary success that we have invited him to join us again next year. Dr. Paul has
designed and taught introductory film courses and independent study programs at Haverford
College, and he has already published numerous articles and reviews relating to film studies
(including 75 articles as film reviewer and features writer for The Village Voice). These are
both distinguished junior appointments, and the Literature Section feels that with these we can
continue to maintain the very high standard that we have set for ourselves.
The broad range and general excellence of our faculty may be seen by citing a few highlights of their activities.

Professor A. R. Gurney, Jr. had a new play, *The Golden Age*, open in London during March 1981. Professor David Thorburn was a visiting professor for a special summer term in the Broadcasting Division of the Speech and Drama Department of George Washington University this past May. Professor Ruth Perry has received a National Endowment for the Humanities (NEH) grant to convene a meeting at MIT of the Northeastern American Society for 18th-century Studies; the event will feature a baroque concert, an 18th-century banquet, and an exhibition of scientific instruments in the Compton Gallery. Professor Irene Tayler, outgoing Chair of the Literature Section is Chair of the Supervising Committee of the English Institute (this means officer in charge of the Institute for 1981) and will be giving the welcome address to the 40th meeting in September. Professor Susan Dickman won a Leverhulme fellowship, granted by National British Universities; she has been a visiting fellow of Collingwood College at the University of Durham in England. Professor Stephen J. Tapscott has been nominated for both the Pushcart Prize in poetry and the London Observer prize for poetry. Professor Cynthia Griffin Wolff served as one of a three-person committee to determine the winner of the Foerster Award for the best essay in *American Literature*; she was also asked to serve on the Lowell Prize committee (to award a prize to the best book published by a member of the Modern Language Association). In addition to these, the members of the Section continue to distinguish themselves in several aspects of their profession.

Institute and Section Activities

Professor Gurney was a member of the committee to investigate drama at MIT; he served on the Institute committee on cable TV. Professor David M. Halperin was coordinator of the Wednesday Evening Lecture Series, served as Literature Concentrator advisor, was a member of the curriculum committee of the Literature Section and of the selection committee for interim appointment; he gave a talk at the IAP '81 coordinator's luncheon and was a guest lecturer in STS 400. Professor Alvin C. Kibel gave a lecture in the IAP series for the STS Program; he also gave a public talk under the auspices of STS, "The Darwinian Revolution." Professor Travis Roe Merritt was Director of Course XXI, chairman of the Option Two Supervisory Committee and member of the committee on perspective new Humanities journal at MIT; he also served on the HASS Committee and on the Committee on Undergraduate Admission and Financial Aid. Professor Perry served on the search committee that resulted in the appointment of Dr. Mullaney, and was an IAP organizer; she also served on the Western Tradition committee and was an AAUP representative. Professor Robert N. Scanlan ran the Dramashop. Professor Tapscott was Department coordinator for IAP 1981, and served on the Writing Program guest readings committee; he was Section coordinator of collaborative IAP courses. Professor Tayler was, until late spring, Section head of the Literature Section; she also served on a committee to examine the MIT-Wellesley exchange, served as freshman advisor, read admissions folders, and attended biweekly meetings of "resource persons" (mainly students and administrators) convened by President Paul Gray, fall semester. Professor Wolff served on the Section curriculum committee; she chaired the committee to investigate drama at MIT and served on the Shakespeare Ensemble steering committee; she succeeded Professor Tayler as Chair of the Literature Section.

Publications

Professor Louis Kampf published "The Degradation of Academic Work," in a special spring 1981 issue of *Radical Teacher*, of which he was editor (writing an introduction to the volume). Professor Halperin published "Solzhenitsyn, Epicurus, and the Ethics of Stalinism" in *Critical Inquiry* and "Continuities in Solzhenitsyn's Ethical Thought" in *Solzhenitsyn in Exile: Critical Essays and Documentary Materials*. Professor Kibel published "Discourse and Story in Literature and Film," a review article for *University Film Study Quarterly*. Professor Perry published *Women, Letters, and the Novel*, "Women in Tristram Shandy" in *Studies in Voltaire and the Eighteenth Century*, "Anality and Ethics in Pope's Late Satires" in *British Journal of Eighteenth-Century Studies*; she published an edition of George Ballard's *Memoirs of Several Ladies*; her article, "The Veil of Chastity: Mary Astell's Feminism," was reprinted in *Sexuality in the Eighteenth Century*; and she published a review in *Philological Quarterly* of Janet Todd's *Women's Friendship in Literature*. Professor Tapscott published "Whitman in Paterson" in *American Literature* and the following poems: "Oats" (in *Paris Review*), "In Fairfield" and "It has happened" (in *American Poetry Review*), "Narcissus" (in *Antaeus*), "Lobster" and "This" (in *The Literary
School of Humanities and Social Science


Papers and Conferences

It would be too lengthy to list each public address individually; however, the faculty of the Literature Section presented their work in a wide variety of forums: Professor Kampf in a conference in Antibes, Halperin at Wellesley, the University of Colorado at Boulder, and the University of Southern California; Professor Kibel in the Cambridge Humanities Seminar and before the Partisan Review planning board; Professor Perry at Northeastern and at the Berkshire Conference on the History of Women; Professor Wolff at Columbia University, the University of Massachusetts at Amherst, and on National Public Radio.

Professional Service and Awards

Professor Kampf was part of a film project -- FILM: THE WAY IT WAS -- financed by a grant from the Massachusetts Council on the Arts and Humanities; he serves on the editorial board of Signs and of Radical Teacher; he is on the reprints committee of the Feminist Press, and serves as consultant for Pantheon books. Professor Kibel is vice president of the University Film Study Center and sits on their board of trustees, is director of the Cambridge Humanities Seminar, is a member of the board of consultants of the National Endowment for the Humanities, of the planning committee of the Partisan Review, and of the editorial board of The Nuclear Almanac. Professor Amy Lang has been awarded an Old Dominion Fellowship. Professor Perry serves on the consulting board for NEH, is a consultant for the Massachusetts Council on the Arts, and is an organizer of the Boston 18th-Century Club (of which she is Chair). Professor Scanlan served as professional associate with "Contact Literature in Cross-Cultural Exchanges" (a project at the Cultural Learning Institute of the East-West Center in Honolulu, Hawaii); he was also a reader for the Anderson Playwriting award at Harvard. Professor Tapscott was awarded a fellowship in poetry at the Breadloaf Writers' Conference. Professor Tayler was a reader for PMLA; she was awarded an NEH Senior Scholarship for summer of 1980. Professor Wolff is a member of the editorial board of American Quarterly; she served on the executive committee for the American Literature Section of the MLA (later 19th and early 20th century), and is a member of the board of advisors of Literary Classics of the United States.

CYNTHIA GRIFFIN WOLFF

THE MUSIC PROGRAM

With the beginning of the 1980-81 academic year, the Music Program had a new curriculum. Music history and literature were expanded with composer, genre, and period courses and the music theory program with advanced writing and computer music; the performance groups have an academic equivalent; and several of the elective subjects inched their way into interdisciplinary fields such as research methods of oral music, cognitive aspects of music, musical acoustics, and studies in musical time. These new subjects aim to solidify as well as diversify the undergraduate musical training to suit the interests and needs of our students.

The enrollment has remained stable around the 1,300 figure for the past five years. The distribution of students in the different levels and fields shows the following figures:

<table>
<thead>
<tr>
<th>Subject</th>
<th>fall 1980</th>
<th>spring 1981</th>
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</thead>
<tbody>
<tr>
<td>Introduction to Music</td>
<td>301</td>
<td>219</td>
</tr>
<tr>
<td>Theory Subjects</td>
<td>157</td>
<td>167</td>
</tr>
<tr>
<td>Music history and electives</td>
<td>241</td>
<td>292</td>
</tr>
<tr>
<td>TOTAL</td>
<td>699</td>
<td>678</td>
</tr>
</tbody>
</table>

214
This past year was unusually productive on the part of performance activities and faculty activities alike. The Music Office staged 79 public performances, which had an estimated attendance of 25,000 people. There were 27 concerts presented by guest and faculty artists, 16 noon-hour Chapel concerts, 11 performances by the Chamber Music Society and Brass Ensemble, five by the MIT Symphony Orchestra, two by the Choral Society, three by the Concert Band, one each by the two Jazz Bands and the Early Music Society, two by the Experimental Music Studio, and 11 other Music Section-sponsored events. In addition, the Concert Band had its annual tour and the Experimental Music Studio concert program was also presented at Alice Tully Hall, Lincoln Center, New York. Sponsored by the Humanities Department, the Music Section offered a lecture series commemorating the centennial Béla Bartók year with guest speakers Dr. J. Kárpáthi from Budapest, and Professor Ivan Waldbauer from Brown University. Highlights of the concert programs, which presented works ranging from the 16th century to avant garde and premiere performances, were Franz Joseph Haydn's oratorio The Creation, sung by the MIT Choral Society under the direction of John Oliver; an all-Beethoven program of the MIT Symphony Orchestra conducted by Neal H. Stulberg, conductor-in-residence for this academic year; the Da Capo Players in the Guest Artist Series; and the renewed organ recitals at Kresge Auditorium with Dr. Ingrid Gutberg performing.

Reporting on some of the faculty activities: Professor David M. Epstein, on leave for the academic year, continued his research on the structure of musical time at the Max Planck Institute and the University of Munich, Germany, where he also lectured on the subject.

Professor John Harbison won first prize for his piano concerto at the Kennedy Center Friedheim Awards Competition in Washington, DC, and spent the spring semester on leave from the Institute at the American Academy in Rome lecturing and composing.

Professor John L. Buttrick participated in music festivals in Europe and Crete during the summer of 1980, and gave concerts in Germany, Switzerland, and the US during the past year. He has recorded the Franck Piano Quintet with the Roumanian String Quartet and has further recordings and tours scheduled.

Professor Marcus A. Thompson had a busy touring program, appearing as soloist with Yehudi Menuhin and the Chicago Symphony Orchestra in Mozart's Sinfonia Concertante, with the Chamber Music Society of Lincoln Center, and as soloist and in ensembles in numerous concerts throughout the US.

Professor Lowell E. Lindgren wrote several entries on baroque opera composers in the new Grove's Dictionary of Music, and has published articles such as "Camilla and The Beggar's Opera" in The Philosophical Quarterly, "Ariosti's London Years" in Music and Letters, and "Francesco Gasparini..." in Quaderni della Rivista Italiana di Musicologia.

Stephen Erdely was appointed musicological consultant to the Archive and Publications of the Millman-Parry Collection at Harvard University and continues to be involved in research of Boston musical folklore, on which a survey monograph, "Ethnic Music in America, an Overview," appeared in the Yearbook of the International Folk Music Council, Vol. 11.

Stepping down from the post of Director of Music with the completion of this academic year, I want to express my most sincerely felt gratitude to President Paul E. Gray and through his office to my superiors, past and present, in the administration for their support and confidence in allowing me to serve for the past five years as head of the Music Section and to contribute to the cause of music in the MIT community.

STEPHEN ERDELY

THE WRITING PROGRAM

This was a year of consolidation for the Writing Program. Its three-branched curriculum (creative writing, essay writing, and science and technical writing) attracted increasing numbers of students. Total enrollments were up approximately 20 percent; two newly introduced intermediate-level subjects, The Scientific Essay and Writing and Reading Poems, proved especially appealing.
to students. To supplement the organization of subject offerings into three levels, which was accomplished during academic year 1979-80, the faculty restructured the requirements for the Writing major and the Writing concentration, stipulating in both cases that students select a focus of interest within the general area of writing and that they include advanced-level subjects in their programs.

The Writing Program's teaching activities outside the Humanities Department saw significant expansion. Professor James Paradis, in his capacity as Director of Technical Communication, has arranged with the School of Engineering to extend undergraduate cooperative instruction in writing to every engineering department; with the recent addition of Civil Engineering, six of the engineering departments also offer graduate cooperative instruction. Professor JoAnne Yates has developed an active program of writing instruction for students in the Master's degree programs of the Sloan School of Management. The smaller cooperative programs in the School of Science and the School of Architecture and Planning continued their successful operation. For the first time this spring, the Writing Program offered instruction for faculty as well as for students. Two seminars, taught by Professor Rae Goodell, were filled with faculty representing the full range of ranks and disciplines at MIT.

The Science Writing Program was established four years ago with a grant from the Reader's Digest Foundation. This year, the Reader's Digest Foundation indicated its satisfaction with the development of science writing at MIT and ensured the program's continuance by awarding it a permanent endowment. Professor Goodell is currently working with the Institute's Development Office to raise matching funds. This endowment will allow the Science Writing Program to expand its undergraduate offerings, to continue its lecture series, which has already featured such notable science writers as John McPhee and Stephen Jay Gould, to develop its internship program, and to redefine its graduate program.

Publications

The range of the Writing Program's curricular offerings is reflected in the range of publications -- from poetry and fiction to essays and scholarly or technical articles -- by its staff. Professor Ellen Bryant Voigt's poems appeared in *The New Yorker*, *Ploughshares*, *The Missouri Review*, *The Ohio Review*, and *Antaeus*. Lecturer Robin Becker and Lecturer Fanny Howe contributed poetry to various magazines and reviews. Lecturer Howe's novel *The Blue Hills*, was published by Avon Books. Visiting Lecturer Frank Conroy became jazz critic for *Esquire*. Professor Thomas Postlewait contributed an article on Bernard Shaw and science to *Victorian Science and Victorian Values: Literary Perspectives*, a collection of essays that he and Professor Paradis edited. Professor Paradis also contributed an essay on Darwin's landscapes to that volume; his reviews appeared in *The American Scientist* and *The London Review of Books*. Professor Bernard Avishai contributed review articles to *The New York Review of Books* and *Dissent*. Professor Bernard Avishai contributed review articles to *The New York Review of Books* and *Dissent*. Professor Goodell wrote on the presentation of science on television for the *Columbia Journalism Review*, and Professor John Wilkes coauthored an article about automobile engines for *Technology Review*. Professor Harriet Ritvo coauthored an analysis of 18th-century journalism for *Comparative Studies in Society and History*. Lecturer Steven Strang founded a literary magazine, *The Pale Fire Review*.

In addition to their published contributions, many members of the Writing Program gave public readings of their work or delivered papers at professional meetings. Details of these activities may be found in the archival version of this report.

Professional Service and Awards

Several faculty members performed professional service outside of MIT. Professor Ritvo was a review panelist for the National Endowment for the Humanities; Professor Voigt served in a similar capacity for the Vermont Council for the Arts, and Lecturer Howe for the Massachusetts Council for the Arts and Humanities. Professor Goodell was a member of the American Association for the Advancement of Science selection committee for its Mass Media Fellows program. Professor Chodakowska offered a workshop on writing biography in the Radcliffe Seminars Program.

Professional recognition was forthcoming for these and other activities. Professor Goodell was elected a Fellow of the American Association for the Advancement of Science. She, along with Professors Postlewait, Voigt, and Wilkes were awarded Old Dominion Fellowships for research and
writing. Professor Dobrin won a National Endowment for the Humanities Summer Seminar Fellowship, and Lecturer Becker received a residence grant from the Wurlitzer Foundation artists colony in New Mexico.

The Writing Program's curricular links to other Schools in the Institute were reinforced by other faculty activities. Professor Paradis served on the Institute Committee on Faculty-Administration; he and Professor Ritvo acted as consultants to the Committee on Educational Policy's subcommittee on a writing requirement. (The results of the subcommittee's deliberations -- that is, whether a writing requirement for undergraduates is instituted and, if so, how it is implemented -- are obviously of great interest and importance to the Writing Program.) Program faculty offered a variety of IAP activities; several served as freshman advisors or read admissions folders. In conjunction with President Gray's inauguration, Visiting Lecturer Conroy organized a series, "Writers Read at MIT," which attracted large audiences to hear such writers as Russell Baker, Norman Mailer, and Ann Beattie. In addition, Professor Avishal coordinated a series of talks by distinguished editors.

Finally, the Writing Program conducted several searches in 1980-81. Dr. Barbara Gastel, who received her M.D. from the Johns Hopkins University, will join the science writing staff as an assistant professor. Dr. Charles Sides of Clarkson Institute of Technology will become a Lecturer in technical communication, with primary responsibility for the undergraduate cooperative programs in the School of Engineering. The most elaborate search was for a new director of the Writing Program. This year was an interim period in the Writing Program's administration. Professor Peter H. Smith, Head of the Humanities Department, served as acting director of the Program, and Professor Ritvo served as assistant director. In the fall of 1981, Dr. William Bennett, a science writer of distinguished national reputation, will join the Writing Program as director and associate professor.

HARRIET RITVO

COURSE XXI

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<tr>
<th>Humanities and Engineering</th>
<th>XXI-A</th>
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<tr>
<td>Humanities and Science</td>
<td>XXI-B, 1</td>
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<tr>
<td>Humanities and Science</td>
<td>XXI-B, 2</td>
</tr>
</tbody>
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The Course XXI office continued to perform its many functions in 1980-81 under the direction of Professor Travis Roe Merritt in the fall semester and Professor Arthur D. Kaledin in the spring, ably aided by Virginia Sorenson, Course XXI administrative assistant. These functions include administering the many undergraduate major programs of the Humanities Department; registering and counseling Course XXI majors and in many ways looking after their well-being; organizing and publicizing various annual events (e.g. the Humanities Department Open House, Academic Midway, Commencement Festivities, etc.); preparing brochures and Bulletin copy for XXI programs; coordinating the Option II program with Science, Technology, and Society; and either sponsoring or participating in discussions about modifying or improving disciplinary and interdisciplinary programs within the Department.

The number of Course XXI majors declined slightly this year (66, as compared to 69 in 1979-80). Seventeen undergraduates received degrees in June; six of these received two degrees and one received three. Our graduates as usual have resourcefully moved in many different directions -- to graduate and professional schools (in chemical engineering, transportation, medicine); to industry (aeronautics, construction); and to the military with ROTC commissions. Technical writing, publishing, veterinary medicine, and computer programming are other fields this year's graduates are entering, or preparing to enter. One student has started his own computer company and another is building a house this summer using old techniques of joining and carpentry in preparation for a career in restoration and conservation. It should be noted that in 1981 Course XXI sent no students on to graduate work in the traditional humanistic disciplines.
Programs

The Option II program, managed cooperatively by Course XXI and the Program in Science, Technology, and Society (STS), continues to attract able students. This year, in conjunction with the Option II Seminar, a monthly colloquium was established, with discussions led by Professors Leo Marx, Smith and Alvin C. Kibel. The Seminar next year will be conducted by Professors Kenneth Manning of STS and Kibel of the Literature Section of the Humanities Department.

A significant restructuring of the Writing and Literature major took place this year (see Courses and Degree Programs for details). In view of the too often lamentable quality of undergraduate thesis in Writing, the Writing Program has decided to tighten requirements for the thesis; and indeed other programs in the Department are reviewing the problem of the undergraduate thesis, which epitomizes the difficulty of constructing programs for a handful of undergraduate majors, many of whom enter these programs late in their careers at MIT.

Of the 17 undergraduates who received their degrees in June, four were in the XXI-A Program (two in Option II, one in Music, one in Literature); two were in XXI-B, 1 (both in Literature); and 11 were in XXI-B, 2 (three in Foreign Languages and Literatures, two in Literature, one in Anthropology/Archaeology, two in Music, one in Religion, one in Writing and Literature, and one was a major departure in Psychology and Visual Arts).

Course XXI Honors

Josephine D. Lee, Class of 1982, won an I. Austin Kelly III Prize for Excellence in humanistic scholarship, as did Thomas J. Misu, Class of 1981, (Biology). Lincoln A. Ross, Class of 1982, won the First Place Robert A. Bolt Poetry Prize; Peter F. Cerrato, Class of 1983, won the Second Place Bolt Poetry Prize. E. Sarah Slaughter, Class of 1982, won the McCormack Award for "undergraduate research in areas relating to technology and its application to problems of man, society, and the arts." David Kazdan, Class of 1981, received a William L. Stewart Award. Christopher K. Dorn, Class of 1981, received both the Admiral Edward Cochrane Award and the Domenic Pizziferri Award; and Steven J. Snider, Class of 1982, won an American Legion Award for General Scholastic Excellence. Ms. Lee also won a Uniroyal Undergraduate Research Award.

TRAVIS ROE MERRITT
ARTHUR D. KALEDIN

Department of Linguistics and Philosophy

The year 1980-81 was a productive one as the research synopses which follow indicate. The large number of colloquia and invited seminars also attest to the high level of intellectual activity in the Department.

One of the major faculty initiatives taken in the Department concerns the search for a position in linguistic theory and natural language semantics. The search will continue in September 1981 and we hope to make a permanent appointment by spring 1982.

A standing problem that faces the Department is financial aid for graduate students. The Department was able to meet these needs during the past year thanks to support from sources within and outside of MIT. However, external support for graduate students in the future is expected to weaken given the changing governmental policies for scientific support.

Finally, plans have been made for the removal of the Departmental offices and certain faculty offices to the second floor of Building 20. This move should be completed by the end of 1981. Upon its completion it will bring the linguistics and philosophy faculty and the personnel associated with the Center for Cognitive Science into a single geographical area. This consolidation is a further step in the development of the merger of the two faculties in 1977.

Professor Noam A. Chomsky continues his work in syntactic theory. His book, *Lectures on Government Binding*, was published in May 1981 and an article, "Knowledge of Grammar: Its Elements and Origins" will appear in the Proceedings of the Royal Society of Great Britain. Professor Chomsky's present work is an attempt to provide a comprehensive account of the principles of the theories of government binding, abstract case, semantic roles and their interaction with base, transformational and interpretive rules.

Professor Kenneth L. Hale continues his investigation into the topology of human languages. He is interested in languages whose superficial topological distance from better known European languages appears to be very great. He has been working in the grammar of so-called "non-configurational" languages, including Warlpiri (Australian), Navajo (Southwestern United States), and Winnebago (Wisconsin and Nebraska). In addition he has extended his research to Japanese. His work has led to a particular conception of the X-Bar theory of phrase structure which defines a typology of languages naturally encompassing the so-called non-configurational ones. His published articles during the past year include two on Warlpiri and one on Winnebago.

Professor Morris Halle has been developing his model of phonological representation as a three-dimensional object. This model has made it possible to get a better grasp on a variety of linguistic phenomena. It has brought out the fundamental similarities between accentual phenomena, on the one hand, and various types of harmony and assimilation phenomena, on the other. It has highlighted differences between tonal and other supersegmental phenomena and has led to a better understanding of syllable structure and its role in different phonological processes. Professor Halle has published several articles relating to this work and is currently at work on a monograph with Dr. Jean-Roger Vergnaud which will be devoted to an exposition of three-dimensional phonology.

Professor James W. Harris continues his work on French phonology and morphology and their interaction with each other as well as their bearing on ongoing work on metrical and autosegmental phonological theories. His work has shown that in Spanish, syllable structure is governed by a set of rules that applies to strings of phonemes supplied by the lexicon and gathers them into groups of labeled constituents, and that in addition a set of filters marks constituents as deviant under specified conditions.

His work on Spanish stress shows that all the peculiarities of stress contours in this language previously attributed to an array of lexical diacritics and other exception-marking devices can be made to follow from independently motivated morphological structures plus a single universally available theoretical advice, namely, extrametricality. Professor Harris completed two long manuscripts on this work. Both are scheduled to appear as chapters in a monograph to be published by the MIT Press.

Professor Wayne O'Neil continues his work in the history of the English language and in Germanic syntax. He is currently working on a revised history of English phonology in collaboration with Professor Samuel Jay Keyser, a work of monograph length, which attempts to apply recent results in hierarchical phonological theory to past ages of English in order to determine how English has developed through time from the perspective of this new theory.

Professor O'Neil continues his studies in the syntax of Old Norse skaldic poetry. He has published several articles on this research and anticipates completion of the monograph during the summer of 1981.
Professor John Robert Ross continues his work on poetics and on markedness theory, iconic syntax, phonetic symbolism, and other topics of cognitive interest. He has published several articles in these areas including, "Mannerly" to appear in the Australian Journal of Linguistics, "Robert Frost’s 'Out, Out-'": a way in," to appear in Crossing the Linguistic boundaries and "No negatives in than clauses, more often than not" to appear in Studies in Language.

Philosophy

Professor Ned Block, who was on sabbatical leave this year at the University of California at Berkeley, has continued his research on functionalism and the nature of mental states. He also has been working on the controversy over whether imagery involves pictorial or descriptive representation. He has published articles in The Philosophical Review and The Behavioral and Brain Sciences, and the second volume of his anthology, Readings in Philosophy of Psychology, has been published by Harvard University Press.

Professor George S. Boolos's research on modality and provability continues. He has published articles in Fundamenta Mathematicae and Theoria, and the second edition of his Computability and Logic, coauthored with Professor Richard Jeffrey of Princeton University, has been published by Cambridge University Press. He has completed his first year as Chairman of the Philosophy Section.

Professor Sylvain Bromberger, who was also on sabbatical leave at the University of California at Berkeley, has written two papers on the philosophy of language, entitled "Mind, linguistics, and knowledge" and "Natural kinds and natural kind words." He has begun work on a book entitled The Structure of Nescience. He gave an invited paper to the Eastern Division of the American Philosophical Association in December.

Professor Richard L. Cartwright's research has been concerned with the nature of logical truth. During the past year he served on five major Institute committees and was Associate Chairman of the Faculty.

Professor Joshua Cohen began work on the problems of the foundations of democracy, particularly pursuing the consequences of a Rousseauian conception of democracy in light of contemporary work on the relationship between capitalism and democracy. He presented a paper "On Democracy" as part of a Swarthmore lecture series on problems of liberation. During the spring term, Professor Cohen visited at the University of California at Los Angeles and gave a course on the history of modern philosophy, incorporating his research material on Hegel.

While on leave last year, Professor Judith W. DeCew was a visiting scholar at Harvard Law School on a Liberal Arts Fellowship in Law. Her research this fall will deal with the moral foundations of legal thought; in particular, she plans to write on the utilitarian arguments that are used in support of changes in the law of liability. Next year she will be the recipient of an Old Dominion Fellowship.

Professor Paul Horwich's book, Probability and Evidence, will be published by Cambridge University Press early next year. His research in the philosophy of science is concerned with the realism controversy, decision theory and confirmation theory.

Professor Thomas S. Kuhn has published a number of articles, including one entitled "Einstein's Critique of Planck." His work on the nature of scientific change continues.

Professor Edwin W. McCann has completed a paper on a central argument in Kant’s Critique of Pure Reason. He is also at work on a paper on Locke’s metaphysics and on a book entitled Locke on Essence and Explanation. Next year he will also be the recipient of an Old Dominion Fellowship.

Professor Irving Singer has almost finished a new book that deals with philosophical and literary concepts of love from the 12th to the 19th century.

Professor Judith J. Thomson continued work on her book on rights.
FACULTY

One of the major highlights of the year was the appointment of Professor Halle as Institute Professor. He joins Professor Chomsky at that rank, and my colleagues and I are indeed proud that the contributions of these two eminent scholars have been so recognized. Professor Halle had been the holder of the Ferrari P. Ward Professorship in Modern Languages and Linguistics, and we are extremely pleased that he will be succeeded in that position by Professor Hale. Among Professor Hale's many accomplishments is his special expertise in American Indian and Australian aboriginal languages.

Professor O'Neil was the director of an NSF/AAAS Chautauqua-type Short Course in Science entitled "Current Issues in the Theory of Grammar," presented in Memphis, Tennessee, and Iowa City, Iowa. He also appeared in the Maryland Center for Public Broadcasting TV series, "The Language: Thinking, Writing, Communicating." In May and June, Professor O'Neil made a return visit to the People's Republic of China, where he gave a series of invited lectures on theoretical and applied linguistics.

Under recent grant from the National Endowment for the Humanities, Professor Ross will conduct a seminar for college teachers during June and July on the topic "Poetry, Art, and Insight."

Professor Cartwright, having served for two years as Associate Chairman of the Faculty and as a member of several Institute committees, will spend the spring term 1982 on sabbatical leave at Clare Hall, Cambridge, England, where he has been elected a Visiting Fellow.

Professor Bresnan has been selected as a Short-Term Visiting Fellow of the Council of Humanities, Princeton University for 1981-82.

I am pleased to report that Associate Professor Horwich, whose areas of specialization are philosophy of science and theory of knowledge, has been awarded tenure.

Language and Mind

The Language and Mind program, supported by a grant from the National Endowment for the Humanities, is now established and has at present about 10 undergraduate majors. A systematic curriculum is being developed which is known as the Map of Cognitive Science -- a detailed guide to central theories and data in the field. Topics include natural language syntax, psycholinguistics, philosophy of psychology, cognitive neurology, mental representation, automata theory, and human information processing.

Independent Activities Period

Six lectures sponsored by the Philosophy faculty entitled "Philosophical Problems" were given during IAP. Speakers and topics included Professors McCann on "Is This Really the Best of All Possible Worlds?", Thomas Kuhn on "Conceptual Change in Science," and Paul Horwich on "What If Choice Were Predictable?"

Also during IAP the Language and Mind Program sponsored six lectures entitled "Mind-Body Interaction." Speakers were Professors Chomsky, Halle, and Jerry A. Fodor of this Department; Professor Emilio Bizzi, Department of Psychology; Dr. Norman Geschwind, Harvard Medical School; and Professor Judith Kegl, Hampshire College and Northwestern University.

Colloquia

Several colloquia were held during the year. Guest speakers in linguistics included Professors Steven LaPointe, Johns Hopkins University; Jonathan Kaye, Université du Québec à Montréal; William Stewart, Graduate Center CUNY; Edwin Williams, University of Massachusetts at Amherst; John Goldsmith, Indiana University; Jill Carrier Duncan, Rutgers University. Philosophy papers were read by Professors Jay Rosenberg, University of North Carolina; Raymond Smullyan, CUNY; Michael Friedman, University of Pennsylvania; Richard Jeffrey, Princeton University; Scott Soames, Princeton University; Fred Feldman, University of Massachusetts.
School of Humanities and Social Science

Visiting Scholars

As in the past, the Department welcomed many visiting scholars from this country and abroad who spent the year attending seminars and colloquia and exchanging ideas with students and faculty. These scholars included Drs. Keith Arnold, Université D'Ottawa; Cathy Buchanan, University of Chicago; John M. Carroll, Columbia University; Chiba Shiji, Tokyo University; Gerald Delahunty, University of California at Irvine; Francesco D'Introno, University of Paris; Hin-Chung Hung, Oxford University; Joan Mascaro, MIT; and Tarald Tarladsen, University of Oslo.

SAMUEL JAY KEYSER

Department of Political Science

During the past several years the Political Science annual report has regularly focused on the problem of graduate student financial aid. A year ago it was possible to report considerable progress, mainly because of generous actions by the Institute administration. More recently, however, a new and highly ominous threat has emerged from outside the academy. At issue is the future of American social science, not merely of this Department, and the future of equal opportunity in American higher education, not merely the welfare of Political Science graduate students at MIT.

The new Federal Administration has proposed, first, severe reductions in student scholarship and guaranteed loan support, and second, a draconian 80 percent cutback in support for research in the social sciences. The student aid reductions will apply to all fields, but their aggregate impact will be muted at the graduate level for those in which most students have research assistantships (RAs). In the past, social science graduate students have much less frequently been able to finance their graduate study by working as RAs than engineers and natural scientists. The planned reduction in Federal research support, concentrated entirely on the social sciences (including economics), will further and sharply reduce the proportion who can do so in future, even as the option of borrowing disappears for many. Additionally, if enacted as proposed, the Reagan budget will severely restrict faculty research opportunities.

As these threats have unfolded, one bright spot has been the vigorous, articulate public advocacy of the case for higher education, in Washington and elsewhere, by President Paul E. Gray. The Department takes this opportunity to express its appreciation and support.

In 1977, aided by a generous grant from the Sloan Foundation, the Department initiated an undergraduate program in public policy. Its aims were, first, to expand and systematize undergraduate opportunities to combine the study of politics with that of substantive policy issues and, second, to facilitate learning via public service internships. The program has since gained considerable recognition as a successful, ongoing feature of the Department's curriculum. The internship component and its Administrator, Patricia Joffee, won Institute-wide recognition this spring in the form of the Irwin W. Sizer award for "the most significant improvement to MIT education." Moreover, there has been growing agreement in the Department that internship activities and policy-oriented training merit high priority at the graduate as well as undergraduate levels.

In the midst of these positive developments, however, the Sloan grant expired this spring, and the Foundation's policy is that such awards are nonrenewable. The teaching component of the public policy program was not threatened thereby, because it has been fully absorbed into the Department's budget. But the internship component was another matter. It requires special funding both for non-faculty administration and student summer stipends. (Academic year interns normally work for credit rather than pay.)

In order to preserve internship activities, the Department launched two efforts to secure continuing funds. First, it requested a special allocation of Institute funds to cover half the estimated cost of administration during 1981-82; and second, it began an effort to obtain small grants and
summer employment commitments from foundations and prospective employers. The latter, it
should be mentioned, include private as well as public institutions, in recognition of the fact
that an expanding area of employment opportunity entails the analysis of policy constraints and
political risk from a private sector standpoint. As the academic year drew to a close, the
Institute administration acted favorably on the Department's request for partial funding during
1981-82, and preliminary responses of an encouraging nature had been received from several
outside institutions. The fundraising effort will continue to receive very high priority over the
coming year.

FACULTY ACTIVITIES

Professor Hayward R. Alker co-directed the International Political Science Association Conference
on Learning About War Avoidance. Closer to home, he chaired the Department's Graduate Pro-
gram Committee and served as its representative on the Institute Committee on Graduate School
Policy. His monograph, "Resolving Prisoners' Dilemmas," was published by the American Political
Science Association, and he coedited the book, Mathematical Approaches to International
Organizations.

Professor Alan A. Altshuler continued to serve as Head of the Department, and as co-director
of a multidisciplinary, international research program on the Future of the Automobile. Addi-
tionally, he chaired the faculty executive committee of the MIT-Harvard Joint Center for Urban
Studies and was a member of the executive committee of the Center for Transportation Studies.
The paperback edition, with a new chapter, of his book, The Urban Transportation System:
Politics and Policy Innovation, was published during the year.

Professor Suzanne Berger chaired the Department's financial aid committee and served on the
MIT Press editorial board. Her numerous publications included a new book (coauthored with
Professor Michael Piore), Dualism and Discontinuity in Industrial Societies.

Professor Donald L. M. Blackmer continued as director of the Program in Science, Technology,
and Society, and as Associate Dean of the School of Humanities and Social Sciences. Next
January, after a well-deserved sabbatical, he will succeed Professor Altshuler as Head of the
Political Science Department.

Professor Lincoln P. Bloomfield returned from a year in Washington as a senior member of the
White House national security staff. He served on the boards of directors of the World Peace
Foundation, the United Nations Association of the USA, and the World Affairs Council of Greater
Boston. Within the Department, he chaired the undergraduate program committee. And he pub-
lished the monograph, "The Carter Human Rights Policy: A Provisional Appraisal."

Professor Walter Dean Burnham made numerous conference presentations on aspects of American
electoral politics and served as the Department's co-director of IAP activities. His publications
included "The Appearance and Disappearance of the American Voter" (in Richard Rose, editor: Elec-
toral Participation) and "The Constitution and American Capitalism" (in Robert Goldwin, editor: How Capitalistic Is The Constitution?).

Professor Nazli Choucri served as associate director of the multidisciplinary, international
Technology Adaptation Program. She also chaired its policy committee and the Department's
personnel committee. Her new publications included the book, International Energy Futures:
Petroleum Prices, Power and Payments.

Senior Lecturer (part-time) Edwin Diamond served as associate editor of the New York Daily News
and completed the forthcoming book, Sign Off: The Last Days of Television.

Associate Professor Lloyd S. Etheredge published a monograph entitled "Government Learning:
an Overview" (in Samuel Long, editor: Handbook of Political Behavior).

Instructor Thomas Ferguson completed his dissertation, and sent to press an edited volume
etitled The Hidden Election: The Politics and Economics of the 1980 Campaign. He also con-
tributed columns to The Nation and Le Monde Diplomatique.
Associate Professor Ted R. I. Greenwood completed a monograph for the White House Office of Science and Technology Policy, "Assessment of the Role of Science and Technology in Standard Setting by Two Federal Regulatory Agencies," which he is currently revising for publication as a book. He also served as an advisor to the Massachusetts State Planning Council for Radioactive Waste Management, and devoted considerable energy to activities involving the resettlement of Indochinese refugees in Greater Boston. His articles published during the year included "Supply Side Non-Proliferation" (in Foreign Policy, coauthored with Robert Haffa, Jr.).

Professor William E. Griffith served as a regular consultant to the National Security Council and completed a forthcoming book, The Superpowers and Regional Tensions: Russia, America, and Europe. He was on sabbatical, traveling widely, during the spring.

Assistant Professor Emma Jackson was elected secretary of the National Conference of Black Political Scientists and served on its Executive Council. She also participated in a research project monitoring the impacts of Massachusetts' Proposition 2½, and was a member of the Institute Committee on Preprofessional Advising and Education.

Professor Willard R. Johnson served on the boards of directors of the African Heritage Studies Association and the Association of Concerned African Scholars. At the Institute, he served on both the Committee on Foreign Scholarships and the Committee on Equal Opportunity. And he published the article, "Africans and Arabs: Collaboration without Cooperation, Change Without Challenge" (International Journal).

Professor William W. Kaufmann participated in the Brookings Institution project on energy and national security, and contributed the chapter on "Defense Policy" to the Brookings volume, Setting National Priorities: The 1982 Budget. He also lectured at the National War College and the Council on Foreign Relations.

Professor Michael Lipsky was on part-time leave as a faculty member of the Legal Services Institute (LSI). LSI is an innovative training program, focused on the provision of legal and policy analytic services to the poor, for selected Harvard and Northeastern law students and MIT students of public policy. It is funded by grants from the US Legal Services Corporation, ACTION, and the Harvard Law School. Professor Lipsky also served as a member of the Justice Resources Institute of Boston.

Senior Lecturer Louis Menand III continued to serve half-time as Special Assistant to the Provost, in which capacity he chaired or was a member of numerous Institute committees. Outside MIT, he served as a trustee of Bradford College and as vice chairman of the Academic Freedom Committee of the American Civil Liberties Union.

Assistant Professor Stephen M. Meyer completed a book, Nuclear Proliferation: Politics, Technology, and Economics, soon to be published by the University of Chicago Press. He also won a Ford Foundation grant for a major study of Soviet defense decision making and published several articles on that subject.

Assistant Professor W. Russell Neuman chaired the Aspen Institute Conference on Television Research in October 1980. Within MIT, he co-directed the Department's IAP activities and participated actively in the Research Program on Communications Policy. His article, "Differentiation and Integration: Two Dimensions of Political Thinking," appeared in the American Journal of Sociology.

Professor Ithiel de Sola Pool directed the Research Program on Communications Policy and chaired the Inter-university Committee of Concern About Institutional Review Board Practices. His publications included the article, "Japanese and US Media: Some Cross-Cultural Insights into TV Violence" (coauthored with Sumiko Iwao and Shigeru Hagiwara).

Professor Lucian W. Pye was a director of the Council on Foreign Relations, the Asia Foundation, and the World Affairs Council of Boston, and he continued to serve as the Department's placement officer. His publications included a new book, The Dynamics of Factions and Consensus in Chinese Politics.

Professor George W. Rathjens chaired the arms control committees of both the American Academy of Arts and Sciences and the American Association for the Advancement of Science. He also
continued to chair the Department's graduate admissions committee and to co-chair the interdisciplinary Arms Control Program in the Center for International Studies. His articles published during 1980-81 included "Nuclear Doctrine and Rationality" (in Daedalus, coauthored with Professor Jack P. Ruina) and "Reassessing Nuclear Proliferation Policy" (in Foreign Affairs, coauthored with Gerard Smith).


Assistant Professor Richard J. Samuels chaired the Industrial Liaison Program's symposium on "Japanese Industry and Technology" in April 1981, and directed the MIT Japan Science and Technology Program. His articles included "Power Behind the Throne" (in T. MacDougall, editor: Political Leadership in Contemporary Japan) and "Japanese Energy Alternatives" (in Policy Choice).

Professor Harvey M. Sapolsky served as a member of the National Academy of Sciences Committee on Effects of Ionizing Radiation. Within MIT, he chaired the Lincoln Laboratory advisory committee, was a member of the Whitaker College Council, and became Associate Chairman-elect of the MIT faculty. His numerous publications included the book, Health Planning and Regulation: The Decision-Making Process (coauthored with R. Greene and D. Altman).


Assistant Professor Brian H. Smith was a member of the Task Force on Academic Freedom and Human Rights of the Latin American Studies Association, and gave numerous lectures on the topic of human rights in Latin America. He also completed a forthcoming book, The Catholic Church and Politics in Chile, 1920-1980.

Professor Peter H. Smith served as president of the Latin American Studies Association, Head of the MIT Department of Humanities, and Associate Dean of the School of Humanities and Social Sciences.

Associate Professor Deborah A. Stone directed the Department's undergraduate public policy program, and became book review editor of the Journal of Health Politics, Policy and Law. She also published the article, "Obstacles to Learning from Comparative Health Research" (Policy Studies Journal), and prepared a monograph for the US Health Care Financing Administration entitled "Design of a Negotiating System for Physician Reimbursement."

Associate Professor Martha W. Weinberg was a member of the Institute Committees on Educational Policy and on Discipline, and of the Technology and Policy Program steering committee. Her publications included "Boston's Kevin White: A Mayor Who Survives" (Political Science Quarterly).

Professor Myron Weiner chaired the Committee on South Asia of the Social Science Research Council and was president of the New England Conference of the Association for Asian Studies. Additionally, he sent two forthcoming books to press, India's preferential Policies: Migrants, the Middle Classes and Ethnic Equality (with Mary Katzenstein) and India at the Polls: The Parliamentary Elections of 1980.

Appointments

Having completed his doctoral dissertation, Dr. Ferguson was promoted to the rank of assistant professor. Additionally, two new faculty members were appointed during 1980-81. Assistant Professor John R. Freeman, a specialist in empirical theory and political economy, received his doctorate from the University of Minnesota and is currently teaching at the University of Missouri. Assistant Professor Daniel Metlay, who will not be able to join the Department until September 1982,
specializes in the interactions of science, technology, and politics. He earned his doctorate at Berkeley and is now at the University of Indiana.

ALAN ALTSHULER

Department of Psychology

The past year has brought new opportunities and new problems. Current and future years promise accelerated changes. Not only will the new Institute administration bring about new departures, both voluntary and forced by circumstances, but the new Federal Administration is already promising profound alterations in the role of the sciences in our society. Some of the implications of these actual and potential changes are discussed in the following.

TEACHING AND TRAINING

Graduate Program

A significant change in the graduate training program has been initiated during the past year. Heretofore the Proseminar, exclusively for first-year students, has served as an introduction to the fundamentals of our field. In addition, it brought together in a stable group members of the first-year class who, by that means, came to know the faculty and each other. Two motives have resulted in a changed format. First, we have long recognized the need for more systematic and extensive basic training than the Proseminar could offer. Second, the very nature of the Proseminar has precluded participation by students outside the Department. In order to achieve both goals, we have created two new graduate subjects (9.014J, 9.015J, and 9.401). The first of these in the neural sciences (9.014J) included contributions from faculty outside this Department (Professors Michael J. Baum and John D. Fernstrom from Nutrition and Professor Thomas F. Weiss of Electrical Engineering). It was offered in the spring semester just past and will continue through the fall semester (9.015J). The second subject, concentrating in the behavioral areas including perception, cognition, and the psychology of language, begins in the coming fall semester. The revamped Proseminar becomes a one-semester introduction to the faculty and to the major scientific concerns of their fields of work. Restricted as before to members of the first-year class, it should continue to serve its function as a focus for identification of the new students with each other and with the Department.

For the past three years we have not only attracted large numbers of first-rate applicants, but also many accepted applicants have come with their own support. They include three National Science Foundation predoctoral fellows in each of the years 1979-80 and 1980-81 (the total number in our discipline does not exceed two dozen). During the last year, however, we have reduced our number of acceptances to five, anticipating the loss of funding from Federal training grants decreed by the Reagan Administration, including our own very crucial training grant with its 10 fellowships from the National Institutes of Health. We are currently seeking new sources of training funds from industry as well as private foundations.

In the 1980-81 academic year we awarded the unusually large number of 10 Ph.D.s, making a total of 77 degrees awarded since the first in 1965. Some persons may ask why we attempt to continue recruiting and training students at the levels that have been sustained in the past knowing that the job market in academia is very slack. The answer is simply that we believe the substance of what is learned in our field concerning human mentation at levels ranging from language and memory, to the integrative activity of the nervous system responsible for these capabilities, to the single cell which constitutes the basic unit of the nervous system, is and will become increasingly critical to maintaining viable living conditions. At the behavioral level we are witnessing a growing demand for our kind of knowledge in many of the applications of automation in which a human operator is involved as well as in those applications in which the human operator is to be replaced by machines. At the neuronal level, we can do no better than to
reiterate the statement that the nervous system constitutes the last major scientific frontier, and the effort being devoted to its understanding can be indexed by the enormous rate of growth during the last few years of the Society for Neuroscience.

**Undergraduate Teaching**

Despite the lack of a Course program in our field, we continue to offer undergraduate subjects and had an enrollment of 605 students, which approximates registration in the previous year. Enrollment in other aspects of the undergraduate program, including a number of concentrators and UROP students, has also remained stable. The two new subjects, Professor Stephan L. Chorover's subject on Affect (9.68) and Professor Daniel N. Osherson's subject on Human Development (9.90J) have been well received. During the past year we have reopened discussion on the question of an undergraduate Course. The outcome of those deliberations will be determined in the current year.

**Colloquium Series**

As in previous years, our colloquia have provided updating on the latest developments in the fields we represent. These lectures have proved of great value not only to our students and staff but to the members of the community in relevant disciplines. This past year we presented 29 regular colloquia and 28 special seminars. Foreign guest speakers came from England, Germany, Holland, Israel, Italy, Sweden, and Switzerland.

**FACULTY**

We are pleased to report the appointments, to begin in July 1981, of three associate professors, each of whom has been previously associated with the Institute and with this Department in one or another capacity for some time. Dr. Suzanne H. Corkin previously served as research associate, lecturer, and principal scientist and will continue her able leadership of our program in neuropsychology. Dr. Tomaso A. Poggio, formerly of the Max Planck Institute of Tübingen and a frequent visiting scientist in the Department will carry on his work in modeling aspects of neuronal action and adding further strength in the computational area. Dr. Shimon Ullman, for several years a principal research scientist at the Artificial Intelligence Laboratory, will continue his work on theories of vision. The latter two appointments, both leaders in the new field of natural computation, will help maintain and greatly strengthen that important new venture. Here we must record with sorrow the loss of Professor David Marr, who, although only 35 at the time of his death, had already created the new computational discipline and had thereby achieved international fame.

**RESEARCH**

The structure of our research funding is such that during the past year 97 percent of support came from Federal sources. These sources include the National Institutes of Health (68 percent), the National Science Foundation (24 percent), the National Aeronautics and Space Administration (four percent), and the Department of Defense (one percent). Our overall funding ($2.4 million) showed a modest increase over fiscal year 1979-80. But the Reagan Administration, with its avowed intent to reduce funding for research in the behavioral sciences, poses a serious threat to the support of a key aspect of the Department. Unless substitute funding can be found, the current and expected stringencies in funding will have the effect of forcing us increasingly to forsake the riskier, and perhaps the more innovative lines of research, to reduce the scope of behavioral study, and to turn toward research in applied areas.

Three anticipated developments may help us buck the trend. Some help may come to our researchers on the behavioral side of the field from an anticipated Sloan grant to the Center for Cognitive Science. The high priority for research in the brain sciences may be maintained. And,
finally, support for the computational approach to problems of perception and robotry, with its high potential relevance to automation in industry and defense, may be increased.

OTHER EVENTS AND EXPECTATIONS

The first of a series of projected symposia sponsored by the fund in memory of Professor Hans-Lukas Teuber was presented on November 17, 1980. It comprised an all-day program organized by Professor Gerald E. Schneider and Dr. Corkin entitled "On the Origins of Individual Differences in Brain Development," and was attended by well over 150 people, many from distant cities and several from abroad.

During the Independent Activities Period our Department organized and presented several seminars including the now traditional one on Art and Perception. Its attendance indicated an excellent reception.

We look forward with mixed expectations to the impending move of four of our faculty, together with their laboratories, to the top floor of the nearby Whitaker Building. We are pleased that new and better facilities will be available, but worry that although our transplanted colleagues will not be far distant, communications with them may suffer. Ultimately we hope that new space adjacent to the Whitaker Building will become available, allowing the group to reunite.

RICHARD M. HELD

Program in Science, Technology, and Society

By contrast with the period of relatively rapid growth associated with the Program's early stages, this year has been predominantly a time of staff consolidation and development of educational and research plans. The composition of the full-time faculty has remained basically stable. No new full-time members have been appointed and only one has departed, Associate Professor Langdon Winner for a position at the University of California at Santa Cruz. This spring Dr. Peter Buck, who has served for two years as lecturer and assistant director of the Program, was appointed associate professor.

Several noteworthy "newcomers" are Institute Professors Jerome B. Wiesner and Walter A. Rosenblith, who have participated in Program activities this year and expect to be even more fully engaged -- in teaching, research seminars, fund-raising, and other activities -- when they move next fall into the Program's new quarters at 70 Memorial Drive. Another important addition is Professor Michael J. Piore of the Department of Economics, who was appointed Mitsui Professor in January and will hold a half-time appointment in STS. After an extensive search among outside candidates, an Institute wide search committee concluded that Professor Piore met the criteria of the Chair and the needs of the Program more fully than any other available scholar. Professor Piore, a labor economist, will substantially strengthen the Program's concern with the relationship of technological change to the political economy of industrialized societies. Also contributing to that aspect of the Program's work is Associate Professor Emma Rothschild, who specializes on contemporary European and American political and economic issues. Professor Rothschild, formerly director of the Writing Program in the Department of Humanities, has joined the STS faculty with a half-time appointment. Finally, this past spring, the STS Program and the Anthropology-Archaeology Section of the Department of Humanities jointly appointed Sharon Traweek, an anthropologist whose nearly completed dissertation consists of a comparative cultural analysis of two particle physics research labs, one in this country and one in Japan.

All told, the STS faculty next year will include 24 persons, about half of whom are full-time "core" members of the Program. This faculty roster appears substantial, especially by contrast with STS programs elsewhere which are generally made up largely of faculty based in other departments. There are still important subject matter gaps, however. We had hoped, in particular, to
make a joint appointment with the Whitaker College of Health Sciences, Technology, and Management of a specialist on the biological and medical sciences. In the absence of assured long-term funding, our request to undertake a search was not approved.

A more general long-run problem is an imperfect balance in the substantive interests and competences of the faculty taken as a whole. Whereas the STS faculty is, for good reasons, exceptionally strong in history and the social sciences, it can claim only a few members, almost all part-time, whose primary training has been in science or engineering. Given the scarcity of appropriately qualified and committed engineers and scientists, it would be surprising if this were not so. All the same, the Program's presence at MIT makes it particularly important to try to remedy the situation, either by new appointments to the core faculty or by joint appointments with other departments. Next fall a selected group of Institute faculty members will be invited to become Associates of the Program, one device among others for trying to involve engineers and scientists more regularly in Program activities. A series of informal lunch seminars this past year with leading members of the science and engineering faculties helped build more of the connections essential to the Program's success.

EDUCATIONAL PROGRAMS

In developing its undergraduate curriculum, the Program has emphasized two broad areas: the history and philosophy of science and technology, and contemporary problems of science, technology, and society. In each of these areas, the Program now offers three types of subjects: 1) Distribution subjects; 2) other "core" subjects that we regard as necessary for an intellectually coherent curriculum in STS and that we therefore plan to teach on a regular basis; and 3) various more specialized experimental subjects that either reflect the current interests of the faculty or are intended for particular student audiences.

Although enrollments are not yet as high as we would like, the data are too limited to be evaluated systematically. Since the Program is still functioning in an experimental mode, and most STS subjects have only been offered once or twice, the long-term enrollment prospects are not yet clear. Moreover, an evaluation of the Program's teaching record must take into account the general conditions influencing undergraduate enrollments in the School of Humanities and Social Science during a time of rapidly rising commitments to engineering and strongly preprofessional orientations on the part of undergraduates. From that standpoint, this is not the ideal time to be introducing a large number of new courses outside a departmental framework. Two general points can be made, however. First, enrollments have been reasonably strong in the areas which initially seemed most promising and have been given greatest attention, i.e. in Humanities Distribution subjects, which have had an average enrollment of 23 students. Second, enrollments in more advanced and specialized subjects have varied a good deal, with specific reasons for student choice patterns difficult to determine. A crucial factor on the positive side is the gradual growth of a reputation for high-quality teaching on the part of those faculty members who have developed a steady student constituency. Faculty members who have taken research leaves -- a practice which has been encouraged for both budgetary and scholarly reasons -- have not similarly benefitted from a gradual buildup of student awareness of their offerings. Even ultimately successful subjects will have to be offered regularly before they become firmly established and attract a steady enrollment. The picture should become clearer in another two or three years.

In response to the strong undergraduate trend toward engineering, we are developing new subjects intended primarily for engineering undergraduates. Discussions have been held with faculty from the School of Engineering which we hope will lead to the design and collaborative teaching of STS subjects that can be used to satisfy elective requirements in various engineering departments. We are also expanding our undergraduate offerings in an area that one might expect to appeal particularly to engineering majors: the comparative study of economic and technological change in advanced industrial societies. Next year three new Humanities Distribution subjects will be taught: The Automobile: Mass Production and Mass Consumption, The Profession of Engineering: Past, Present, and Future, and Capitalism and Its Critics.

STS subjects have been independently listed in the Institute Catalogue for only two years. During this time discussions have been going forward about whether to propose a separate STS
major. Other possibilities include the development of dual majors, or the creation of combined S.B./S.M. degrees in collaboration with other departments in engineering and science. These decisions, which should be made within the next year or two in the context of the Committee on Educational Policy’s review of the undergraduate curriculum, will help determine the direction in which the Program’s teaching effort should be concentrated.

Good progress has been made with respect to graduate education as well, largely in consequence of an effective working arrangement with the Department of Political Science. Each year we receive many inquiries from prospective graduate students about the possibility of working toward a master’s or doctor’s degree within the Program. Promising students with relevant interests -- particularly those wishing to specialize in the social and historical study of science and technology, science and technology policy, and the comparative study of industrial societies -- are encouraged to apply as degree candidates in Political Science. The Program helps screen those candidates and offers financial aid to a selected few. Those who enroll may then take some of their courses with STS faculty, devise special fields of study for general examinations, and write dissertations under the supervision of an STS faculty member.

We have been pleased and somewhat surprised by the degree of interest shown by graduate students, both prospective and enrolled, and by their generally high quality. There is some irony in this, given the strong initial orientation of the Program toward undergraduate education. It may be that while the difficulty of gaining a firm foothold at the undergraduate level was underestimated, in part because of the strong shift of the marketplace and of student interest toward engineering careers, the potential for building a small but high quality graduate program may be greater than initially supposed. A good argument can be made that the intellectual and real-life complexities of the science-technology-society interaction can be dealt with more effectively at a relatively advanced level of competence. Whether a major effort should be made at the Ph.D. level or at the Master’s level -- in collaboration, for example, with the School of Engineering’s Technology and Policy Program -- is still not clear.

RESEARCH

For the STS Program to flourish at a university like MIT, research must receive high priority. This realization has strongly influenced the initial selection of faculty members for the Program and the subsequent allocation of their energies. Many faculty members in the past two or three years have managed to take research leaves, through sabbaticals; research grants, or national fellowships. Although their comings and goings have not simplified the process of building a consensus around educational and other Program activities, the arguments in favor of ample research time are compelling. Faculty members of the highest quality will not be attracted to an interdisciplinary program like STS, where collegial responsibilities for program development are unusually heavy, unless they can be assured of a supportive attitude toward their research. And the Program, for its part, will prove its merit as much by the quality and significance of its faculty’s research as by any other measure.

Several studies were published, or delivered for publication, during the year. The Reidel Press published *Sophie Germain: An Essay in the History of the Theory of Elasticity*, coauthored by Professor Louis L. Bucciarelli in collaboration with Dr. Nancy Z. Dworsky. Professor Loren R. Graham submitted to the Columbia University Press his book entitled *Between Science and Values*, which explores the ways in which selected 20th-century physicists and biologists have dealt with the social and political value issues emerging from their scientific work. Professor Charles F. Sabel completed revisions of his book on industrial conflict and the sociology of the labor market, to be published by the Cambridge University Press. And Professor Joel Yellin’s lengthy piece on "High Technology and the Courts: Nuclear Power and the Need for Institutional Reform" was the lead article in the January issue of the *Harvard Law Review*.

A number of research plans and proposals were developed this year. Professor Charles Weiner has received support from the National Science Foundation for a study of the ways in which molecular biologists are responding to the challenges and opportunities of genetic engineering. During his sabbatical year he has made good progress on the archival research and interviews which will provide the primary data for this timely research, which flows naturally from his earlier work on the emergence of recombinant DNA techniques.
Funding has been obtained for a research seminar on problems of innovation in the context of the so-called "reindustrialization crisis": how must American industry be rebuilt, if it is to survive in world markets and meet domestic demand for higher quality, more specialized, safer, less costly products and healthier work places? The seminar, which began to meet in February under the guidance of Professors Carl Kaysen and Wiesner, has two purposes: first, to bring managers and labor representatives together with MIT social scientists and engineers; and second, to serve as an exploration of fruitful directions for further research. Each session of the seminar thus far has been devoted to a relatively detailed examination of a particular industry, with presentations by industry executives and, where possible, union leaders.

Professor Merritt Roe Smith has developed a proposal for a multi-year study of the role of the military in shaping technological change in the United States. While the research will have historical dimensions, recent case studies are also planned to illuminate the contemporary role of the military as a sponsor and catalyst of new technology. The study will involve fundamental questions about design and development, invention, and innovation, and will include engineers and people from business and the military as well as humanists and social scientists. Several proposals for work on science and technology in the Soviet Union have been submitted for funding by Professor Graham. The largest of these envisions the creation of a computerized data bank on Soviet science and technology, to be developed in cooperation with the Center for International Studies at MIT and the Russian Research Center at Harvard. The information it would make available about Soviet research and development efforts and Soviet attitudes toward science and technology policy should be useful to scholars, businessmen, and government officials.

Mention of these prospective projects highlights the financial uncertainties the Program faces as it seeks to realize its research goals. Like many other scholars in the humanities and social sciences, the STS faculty is heavily dependent on the National Science Foundation (NSF) and the National Endowment for the Humanities (NEH). The severe budget cuts announced for those agencies have already jeopardized several of the projects just described. For the present, it may be necessary to focus particularly on foundation and other private sources for research funding and other support.

STS FELLOWS

During the 1980-81 academic year the first five research fellows were in residence under the terms of a $500,000 grant from the Exxon Foundation. This year's fellows, chosen from a field of almost 200 candidates, were engaged in a variety of projects. Dr. Naomi Aronson, Assistant Professor of Sociology at Northwestern and a specialist in the sociology of health, has been conducting a socio-historical study of the discovery of Vitamin A. Dr. Barry M. Casper, Professor of Physics and Chairman of the Physics Department at Carleton College, completed a book on a controversial energy policy issue in rural Minnesota and began a more general study on "Scientists and the Politics of Technology." Dr. Gilbert Moore, labor economist and historian, explored theoretical and practical questions concerning the distribution of energy resources to non-white urban communities. Harley Shaiken, a former machinist in the auto industry and a specialist on the social implications of industrial automation, has been studying the impact of computer-based technologies on the industrial work force; he has been given a two-year research appointment to continue his work in collaboration with researchers in the Laboratory for Manufacturing and Productivity.

Dr. Rosalind H. Williams, a specialist on European cultural history, is studying the "appropriate technologies" proposed by radical 19th-century thinkers. A similarly diverse and interesting group of research fellows has been selected for the coming year.

The Mellon Foundation has awarded the Program a grant of $330,000 for the development of a complementary fellows program. Some of our applicants for research fellowships had excellent backgrounds in scientific and technological disciplines and were eager to increase their understanding of the social dimensions of science and technology. They were not, however, surviving a selection process in which a strong research proposal, and the promise of significant publication, were primary ingredients. It was clear that they were, or should have been, candidates for study rather than research fellowships.
The grant from the Mellon Foundation will allow the Program to award four study fellowships per year for three years. We anticipate that the Mellon fellows will for the most part be college or university teachers in fields of science and engineering. They will be chosen on the basis of the coherence of their study plans, the apparent strength of their interest in STS, and their prospects for continued involvement in the area. The fellows will be expected to attend a special STS seminar in which they will be introduced to the literature and assisted in doing research in their particular fields. Beyond this, they will be free to follow other subjects, to do research and reading, and to profit more generally from the intellectual resources of Cambridge. A national competition will be held for the Mellon Fellowships next year, with the first fellows scheduled to arrive in 1982-83. We look upon this new fellowship program in part as a way of making a modest contribution toward enlarging the pool of scientists and engineers concerned with the social dimensions of their fields. We also see it as a way of strengthening the STS Program itself, by actively engaging more scientists and engineers in our activities.

SEMINARS AND LECTURE SERIES

The Program sponsored or cosponsored a number of seminars and lecture series during the year. A faculty seminar series on "Risk and Decision Making," organized in collaboration with the Center for International Studies and led by Professor Eugene B. Skolnikoff, brought together faculty and graduate students from a variety of fields to discuss problems involving risks to public health and safety or to the environment. Sessions of the seminar examined how scientific and technical information needed to assess particular decisions was generated and used, and how the process might, in retrospect, have been improved. Among the topics addressed were "Risk and Decision Making," "Diesel Emission: Health Effects and Policy Implications," and "Assessing Carcinogenicity: The State of the Art."

A second faculty seminar series, on "Quality Indicators of Science," was led by Professor Gerald Holton as part of an NSF sponsored research project on the same theme. The seminar, attended by faculty members from Harvard and MIT along with government and foundation representatives, met three times during the fall term. The sessions were introduced by talks by Derek J. De Solla Price (Avalon Professor of the History of Science, Yale University), Lewis Branscomb (Vice President and chief scientist of IBM and Chairman of the National Science Board), and Daniel Yankelovich (Yankelovich, Skelly & White). The goal of the seminar was to suggest ways in which traditional assessments of science might be complemented and made more useful by measures which take into account other, more qualitative dimensions of the scientific enterprise.

The Program also continued its own colloquium series, for the second year under the direction of Professor Smith. Eleven lectures were given, primarily by outside speakers, on such topics as "Health and Safety Issues of Reindustrialization" (Anthony Robbins, Director, National Institute for Occupational Safety and Health), "The Relevance of Social Science to Medicine" (Leon Eisenberg, Professor and Chairman, Department of Social Medicine and Health Policy, Harvard Medical School), "Perspectives on the Synfuels Program" (John Deutch, Professor of Chemistry, MIT), "Literary Technique and Technology" (Richard Poirier, Professor of English, Rutgers University), and "Secrecy and Scientific Research" (Sissela Bok, Lecturer, Harvard-MIT Division of Health Sciences and Technology).

This year, as last, the Program joined with the Technology and Culture Seminar in sponsoring a variety of public events, including a major public forum on "European Nuclear Disarmament," featuring the noted English labor historian, E. P. Thompson, and a spring semester lecture series, organized by one of our research fellows, Mr. Shaiken, on "Reindustrialization." That series included panel discussions on "The Implications of Reindustrialization" and on "Who Pays for Reindustrialization," as well as a public debate between Professors Bennett Harrison and Lester C. Thurow.

Other Events of Note

Several awards received by STS faculty members merit special mention. Visiting Professor Holton received a Guggenheim Fellowship and was named Jefferson Lecturer by the NEH, the first scientist to receive that distinguished award. His talk, delivered in Washington and in Boston
in May, explored the question "Where is Science Taking Us?" Professor Graham was elected a Fellow of the American Academy of Arts and Sciences and was selected as an exchange scholar to the Soviet Union by the National Academy of Sciences and the International Research and Exchanges Board; he will do research in the USSR next spring, while on leave as a Fellow at the Kennan Institute for Advanced Russian Studies in Washington. Professor Sherry R. Turkle was the recipient of both Guggenheim and Rockefeller fellowships and has spent the year writing a book on how computers are changing people's values, modes of perceptions, and views of the world. Professor David F. Noble was on research leave as recipient of a fellowship from the Oral History Program at Duke University.

A great deal of planning has been done this year for the Program's forthcoming move to new quarters at 70 Memorial Drive which will be shared with the Sloan School of Management. Following the move, the Program will for the first time have adequate office space and facilities for lectures, seminars, conferences, and other Program activities. The move into the new building will be officially celebrated in December by a two-day symposium with speakers and panelists from MIT and elsewhere.

This "environmental" change is being accompanied by a change in the Program's management as well. This spring Dr. Kaysen, Skinner Professor of Political Economy and former Director of the Institute for Advanced Study at Princeton, was named Director of the Program, effective July 1. The Program is most fortunate that as eminent, energetic, and experienced a person as Professor Kaysen has agreed to take charge.

Permit me to conclude on a personal note. To have had a part in shaping the STS Program over the past four years has been an exciting experience, occasionally frustrating but always rewarding. The Program's goals, difficult though they will be to realize, are well worth working for. My thanks go to all those who have shared the experience, for their enthusiasm, their good ideas, and especially their friendship. I hope and intend to remain involved from my new vantage point in Political Science.

 DONALD L. M. BLACKMER
Sloan School of Management

The major activities of the Sloan School continue to focus on research and on the education of both management professionals and of the educators of the next generation of management professionals as well as the researchers of tomorrow.

The core mission of the School has remained essentially unchanged from what it has been from the School's inception; we continue to seek to have a significant impact on the practice of management and on the furtherance and improvement of the responsible professionalism with which that practice is pursued.

Our efforts have not been cast in any singular ideological mold nor designed in uniform pedagogical cant. We have no single set of prisms through which we insist that the verities of the universe can be perceived, nor a single set of educational tools which we insist on using because they will guarantee the effective dissemination of those truths. In our research and teaching, our bent is pluralist and pragmatic.

There has been, however, a faith of a different sort which underlies this strategic mission of the School and it is one which has buttressed and supported its efforts from the start. We continue to have this faith in the power of ideas and in the import which their generation and dissemination can have for the practice of management, and indeed of our lives. The faculty and the staff of our School, the participants in our current programs, the alumni and alumnae of programs past or to come -- all have shared and continue to share one attribute in common. All of us have believed and continue to believe that fundamental understanding surpasses in worth surface slickness. All of us have believed and continue to believe that the capacity for careful thought and analysis surpasses the glitter of clubby membership. All of us have believed and continue to believe in the seeking out and nurturing of quality of mind and excellence. And equally important, all of us have believed and continue to believe that the generation of such powerful analytic tools as we can hone and shape must be wrought in the ever-present context of the real world. Our analytic understanding should indeed please the purist, but it must, in addition, be sparked by the search for understanding and enlightenment of the major managerial tasks and problems of our times and of future years.

The following sections report on the School's teaching programs and research during the past year and on the broad array of related professional activities in which the School's faculty and staff have engaged in that same period. Our undergraduate program, but principally our master's programs and the executive education programs, are our major opportunities for affecting the quality and practice of management, not only in this country but in others, through the dissemination of our own and others' ideas impinging on that practice. Our doctoral program is aimed essentially at the training of future educators of management professionals and at training these persons to engage in the serious research which must underlie any successful efforts at professional education. Our research activities have continued to create and replenish intellectual capital as the basis for understanding and resolution of important management issues not just in relation to today's headline perspective but geared for the longer term and thrust. All of these activities continue to merit the high national and international repute of the School's programs and research.

As noted in last year's report, the School has developed and has begun to implement a plan which has as its purposes the fostering of a renewed uniqueness in the School's major teaching programs, the strengthening of research in the School, the fostering and articulation of a clearer, coherent context for our teaching and research, and the consequent enhancement of the visibility and impact of the School's programs and research in the world.

The plan restated our broad strategies; the advantages discernible in modest but not "precious" size; in the ongoing concern with excellence in the quality of mind of our program participants,
Among the prerequisites for attaining the School's goals we included the upgrading of the School's physical plant and the expansion of that plant to permit us to admit additional program participants in both our two-year Master's program and in our Senior Executive Program, to push us away from what are now too small market shares in these program markets. Even more significantly, these changes will provide adequate student and staff work space and generally improve the quality of student and faculty life and work at the School. The plan also called for investments in a small number of additional faculty to staff a portion of the expanded enrollments we expect, and to permit further expansion of research activities, largely sponsored, in many of the management fields taught at the School. The physical plant improvements will allow us to use current staff in a much more efficient and effective fashion in the staffing and delivery of our programs. We could, in consequence of these improvements in working and teaching space, improve our productivity as well as the general quality of student, faculty, and staff work life.

The plan also described some of the other resources, beyond improved physical plant, which would be required for improvement of the School's programs and the expansion of its research and for the fostering of better connections and stronger support organization for all of these teaching and research activities. Among these were investments in adequate support structure for improved corporate, alumni, and media relations, and the development of a coordinated Sloan School-MIT effort to expand the School's general and chair endowments. To bolster the generation of renewed intellectual thrust, we also need a renewal of communication within the School, between the School and individuals elsewhere at MIT, and in organizations outside MIT.

During the past year we have made some substantial progress along a number of the investment dimensions described in the plan but still have a way to go in the meeting of our other investment needs and in the development of our external communication efforts.

The School's physical plant needs for the intermediate term have been substantially addressed through the joint Sloan School and MIT collaborative investments agreed upon last year. These will permit us in the intermediate term to seize effectively many of the opportunities we can discern for the School's continued success in the next decade. We expect that by fall 1981 the construction of new seminar, classroom, and support space for the School's use in 70 Memorial Drive will have been completed as will the construction of One Amherst Street. The many interdepartmental research centers and laboratories in which Sloan School faculty and staff play at least a major, and often the substantial, intellectual role will thus be housed in consolidated proximity to the rest of us at the east end of the campus. We shall also have a bridge linking 50 and 70 Memorial Drive, to facilitate our program management logistics and communication among ourselves.

By the summer of 1982, we hope to have completed the construction of an additional facility at the Endicott House property which will permit the housing of an additional 25 participants in our residential Program for Senior Executives and for School use for other executive programs we may develop in the future. That facility will include a tiered classroom, and a lounge and working space for the program participants. By summer of 1982, we should have completed a major renovation of the lower and first floor levels of the Sloan Building to permit much improved program and student working space, eating facilities for Sloan School students and staff (who currently use the make-shift facilities of the "Ploughman's Pub"), and modifications of a minor sort on the third, fourth, and fifth floors of the Sloan Building to permit a more appropriate rearrangement and consolidation of faculty and staff in both the Economics Department and in various major groupings of the Sloan School. These renovations should improve effective teaching and research activities by facilitating the communication necessary within and among related subsets of intellectual disciplinary and functional efforts to accelerate an overall review of School programmatic efforts.

During the year we have made progress as well in setting in place, at least in part, the organizational underpinnings for the much-needed enlargement and improvement in the School's corporate, alumni, and other informational relations activities.

We must continue to seek and obtain help from the central MIT administration and of all of our alumni and corporate and individual friends in planning future coordinated efforts at developing
the School's additional endowment resources, resources for graduate fellowship support in our
doctoral program, and the miscellaneous support so vitally needed for the many diverse con-
siderations which, though minor in dollar value, make the difference between an outstanding and
a simply satisfactory working climate for faculty, staff, and students at the School. We must
continue to seek additional funds for endowed chairs for the School to give explicit recognition
to the outstanding quality of our faculty. Here we lag substantially behind our competition's
achievements. In all of these resource development activities, we shall need to build opportunities
for coordinated efforts between MIT and the School.

The potential intellectual advantages of the School's further linkages with various facets of the
Institute are many. Being in and of MIT gives the School a unique advantage on which we all
can continue to play in the future, and gives the School and the Institute a continued edge on
the kinds of problems we can tackle intellectually and educationally. That linkage, however, if
not carefully, thoughtfully, and creatively fashioned, can by the same token threaten to engulf
us in bureaucratic mire or in diminishing visibility. We must continue to assert the independent
as well as interdependent vitality of the role of management education and research at MIT --
assertions which must come not only from all of us at the School but from the key central admin-
istrative officers of the Institute and of the other Schools and major centers of intellectual
activity. That will clearly require continued efforts on the part of the School to better inform
the rest of the Institute about what we are and how we work, as well as reasonably receptive
ears and arms at other parts of the Institute.

The School has every reason to be confident in the availability of that central support and of
the forthcoming willingness to march together in pressing for the future strengthening of the
School's already high-quality teaching and research efforts. In turn, we have already begun to
discuss how we might better direct our own internal energies to re-mold our many individual,
diverse, and varied talents in ways that will shape and create more exciting programs and out-
standing research efforts. Together, those coordinated School and MIT campaigns cannot help
but result in the revitalization of the Sloan School of Management's unique place in management
education and in sharpening its national and international image as the premier "jewel of a school"
which it is and which its quality and style clearly will continue to warrant as a label for the future.

TEACHING PROGRAMS

Undergraduate Program

The overall level of undergraduate enrollment in Course XV has remained about constant, with a
total enrollment for 1980-81 of 100. During the academic year, 41 students received the Bachelor
of Science in Management. Of these, 17 were in Management Science, four in Behavioral Science,
two in Dynamics of Management Systems, and 18 in approved Special Programs. Although only
one of the degree candidates this year received an additional S.B. (in Economics), two had
previously received S.B. degrees in engineering, and the interest in double degrees in science
or engineering and management remains high. There are nine students currently enrolled in
approved programs that will lead to double degrees in 1982.

Our undergraduate core subjects continue to attract a sizable number of students from other
Institute programs. During the past year there was a total of 405 subject enrollments in our five
major core undergraduate subjects by students from other Schools. This is equivalent to 48
additional full-time students.

The Undergraduate Management Game was offered for the second time in the January Independent
Activities Period (IAP) and is now established as a regular IAP offering. Of the 23 students
who participated last January, 13 were undergraduate management majors and 10 were engineering
or science majors (three of whom have already received approval for an additional S.B. in
Management).

The Student-Faculty Committee was again active, meeting on a regular basis; assisting in the
School's freshman open house and other orientation activities for freshmen; and producing the
second edition of the undergraduate resume book, which was even more effective this year in
developing placement opportunities for seniors. Beginning this year student officers of the
Student-Faculty Committee also serve as student members of the Undergraduate Program Committee.
Stephanie Acker, an active member of both of these committees, received this year's Sloan School Senior Award for high scholastic standing, leadership, and professional promise. Another senior, Nick B. Adams, who served as vice president of the Institute's Undergraduate Association, and Samuel M. Austin III, a junior and leader of the Black Student Union, received William L. Stewart Awards presented by the Institute for outstanding contributions to extracurricular life at MIT.

The program was chaired by Professor Jeffrey A. Meldman, with Esther Merrill serving as program coordinator. Professors Thomas J. Allen, Jr., Gabriel R. Bitran, Stan N. Finkelstein, Stephen C. Graves, and Peter M. Senge served as undergraduate advisors, together with Professor Meldman and Ms. Merrill. Professor Jawaid A. Ghani served as the Sloan School's coordinator for MIT's Undergraduate Research Opportunities Program.

Master's Programs

The master's programs continue to attract a large and well-qualified applicant pool. This past year 1,805 individuals competed for approximately 160 places in our two programs -- the two-year Sloan master's program and the 12-month accelerated master's program. This represents a seven percent increase over the number of applications received in the previous year for approximately the same number of student places. While the substantial increase in applications is gratifying, it also accentuates the need for continual improvement in our admissions process.

Academically, our programs continue to be solidly built on discipline-based and functional studies, which form the foundation upon which students develop their applied management skills at Sloan. This past year, the Master's Program Committee intensively reviewed the curriculum of the accelerated program. Although no changes were made in the number or content of core subjects, the committee decided to introduce more flexibility into the summer session of the accelerated program through waiver examinations for core subjects. This change made feasible the introduction of additional subjects in the summer, creating a much broader and more balanced learning experience during this period.

The Committee also analyzed the role of our master's theses in contributing to the students' learning experience. They recommended an increase in the number of applied thesis opportunities being made available by our faculty. These applications take two basic forms -- those which center on a question or problem facing an organization or sets of organizations and those which focus on problems within a specified intellectual area. The faculty are responding to these recommendations and most areas of concentration are planning to make these opportunities available to students in fall 1981.

Our Communication Program, started last year, has begun to flourish. Professor JoAnne Yates has been working with both individuals and teams of students to increase their skills in written and oral communication. The students have responded enthusiastically, recognizing the importance of these abilities in management.

In addition to continued progress in academic affairs, we are moving ahead in our efforts to professionalize our programs' administrative services. One of our major challenges stems from the increasing number of applications we receive. We are in the process of creating a data support system which will provide us with much better information regarding our pool of applicants and the status of our decision-making process.

We continue to be concerned about the ability of master's students to finance their education through personal savings and existing loan programs. As the absolute gap between the maximum Guaranteed Student Loan and the cost of our programs continues to increase, we must find ways to make available the funds students need to attend our master's programs.

The School honored several master's students for academic and professional excellence. Barbara A. Siegel and Robert D. Drescher were named Proudfoot Fellows and received fellowship awards established by the Alexander Proudfoot Company at the Sloan School to honor the memory of its founder and to develop an awareness that productivity is a major concern for American industry. William L. Burke, Jr., received the Thomas M. Hill Prize for a second-year student who demonstrated excellence in the field of accounting. The prize was established by the late Professor Hill's friends and colleagues to honor his memory and distinguished service to the School for 30 years. Neil S. Novich was named the Henry Ford II Scholar, an award established at the
School by the Ford Motor Company Fund and presented annually to a second-year student who has demonstrated unusual academic and professional excellence. This year we also presented the Brooks Prizes, established by E. Pennell Brooks, first Dean of the School, to honor the author of the best master's thesis, to Kevin K. Steiner, winner for 1978-79, and to Peter M. Guadagni, winner for 1979-80. Two honorable mentions went to Amar Gupta and to David C. Naugle.

Minority recruiting in 1980-81 included visits to a half dozen black college campuses, letter campaigns to minority college students with strong academic skills and a business orientation, and extensive personal contact with accepted minority applicants. A half-time research assistant who was a minority student at Sloan assisted in these efforts. Funding for enrolled minority students with financial need was strengthened, and a brochure profiling five minority graduates was prepared for distribution to future minority applicants. At the completion of the admissions process, a total of 98 minority and women applicants had applied to the Master's Programs, and 18 had been admitted.

The following data highlight some of the major characteristics of the Classes of 1981 and 1982 for both the master's program (two-year) and the accelerated master's program (calendar year).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Sloan Master's Program</th>
<th>Accelerated Master's Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex: Female/Male</td>
<td>1982: 31/86</td>
<td>1982: 8/34</td>
</tr>
<tr>
<td>Percent with full-time</td>
<td>1982: 73%</td>
<td>1982: 100%</td>
</tr>
<tr>
<td>experience</td>
<td>1981: 74%</td>
<td>1981: 100%</td>
</tr>
<tr>
<td>Mean undergraduate</td>
<td>1982: 4.4</td>
<td>1982: 4.5</td>
</tr>
<tr>
<td>Grade Point Average*</td>
<td>1981: 4.3</td>
<td>1981: 4.3</td>
</tr>
<tr>
<td>score**</td>
<td>1981: 624</td>
<td>1981: 628</td>
</tr>
</tbody>
</table>

* On 5.0 scale (excluding most foreign students).
** National average is approximately 460.

In 1980-81 for the first time, nearly all of the graduating master's students who sought and found employment did so through the facilities of the Placement Office. This includes students who accepted positions with organizations that interviewed on campus, students who took full-time positions with former summer employers that had, in turn, first interviewed on campus, students identified by employers through the resume book, and others who responded to Correspondence Opportunities that reached the Placement Office by mail or personal contact. This gratifying record can be attributed to the Placement Office's ongoing work both with students, individually and in groups, to help them make realistic assessments of their interests and abilities, evaluate career choices, and develop and appreciate the value of interpersonal skills; and with individual organizations to help them adapt their recruiting efforts to the Sloan environment.

A few employment trends are noteworthy. The major consultancies recruited at Sloan this year with special vigor. The number of investment banks present rose from three in 1979-80 to 11. For the first time in several years, the country's major commercial banks were competitive both in terms of professional opportunities and salaries. Fully 14 consumer marketing organizations interviewed Sloan students; in 1979-80 the number was three.

Thirteen oil companies recruited on campus, a record. Recruiting by mature manufacturing firms dropped, and the slack was taken up by the newer high-technology companies as well as consulting firms.

Factors other than career opportunities per se complicated the choices graduating students made in 1981. One powerful influence was the dual career, both for those students presently concerned and for those looking forward to such concerns. Another, "quality of life," took on new importance, as significantly fewer students indicated the willingness to trade off commitments to personal relationships and outside interests for all-consuming work, no matter how remunerative. Indeed, in 1980-81 for the first time, six students turned down offers from the most prestigious consulting and investment banking firms for exactly these reasons, while a larger number of
students did not present themselves as candidates for those opportunities in the first place. In addition, an increased number of graduating students conducted extensive job campaigns and then accepted full-time employment with their former summer employers. Recruiting organizations have noted this trend and worked to develop meaningful summer opportunities for first-year students. In 1980-81, 34 organizations recruited on campus for summer employment, up from 20 the year before, and another 41 mailed in Correspondence Opportunities.

During the past several years, a small number of consulting firms have accelerated and intensified their recruiting of both first- and second-year students at the nation's top business schools. This year, Harvard, Stanford, and Sloan issued recruiting guidelines designed to restore a sense of balance to the placement process, and to eliminate pressures on individual students to make premature job decisions. The guidelines have had a salubrious effect. The consulting firms have perceived that they have ample opportunity to meet their employment needs within the regular recruiting period and adjusted their recruiting tactics accordingly. The situation remains fragile, however, and the Placement Office continues to monitor potential problems.

A total of 166 organizations recruited students on campus in 1980-81, and another 275 notified the Office of opportunities by mail or telephone. Approximately 130 of the 156 graduating students participated in the placement process. The preliminary (June 1, 1981) mean starting salary was $34,400 (1980: $32,000).

The Master's Program Committee was chaired by Professor Donald R. Lessard, who set an important agenda for the past year's work. Dr. Jeffrey A. Barks, director of the School's master's programs, gave unstinted and imaginative administrative direction to both programs. Miriam Sherburne, director of admissions and graduate registration officer, was the recipient of the James N. Murphy Award, given by MIT for outstanding service to students at the Institute, an Institute-wide recognition of what all of us here at the School have come to expect of Ms. Sherburne's service to students and staff alike. Ms. Sherburne continues to have the valuable administrative support of Harriet Barnett, coordinator of the master's programs. Paula B. Cronin and her staff continue to build on an already fine placement service which serves our students and the employers of our students smoothly and effectively throughout the year.

Joint Program in the Management of Technology

Progress to the point of realization occurred in the development, approval, and start-up of the new Joint Program in the Management of Technology. Developed and administered jointly by the Sloan School of Management and the School of Engineering, this 12-month, full-time program leading to the new MIT degree of Master of Science in the Management of Technology was approved by the MIT Corporation in March 1981, and received its first pilot class of seven students in June 1981.

Aimed at engineers and scientists with a minimum of five years of work experience, the Joint Program will prepare these professionals for more senior roles in government and industry where they will generate and manage technology-based endeavors. Faculty drawn from management and engineering are developing and implementing a revolutionary curriculum that includes eight subjects never offered before at MIT. These include, among others, technology planning, marketing and manufacturing interfaces with technology, cases and projects in engineering management, and managing professionals.

Conceived by Professors Edward B. Roberts of the Sloan School and J. Herbert Hollomon of the School of Engineering, now respectively director and deputy director of the Joint Program, the program structure was evolved and the curriculum developed by a joint faculty committee of both Schools. Under the able guidance since September of Jane M. Morse, program manager, the concepts and details of the new program and degree were evaluated and approved by graduate faculty committees of both Schools and then by the Committee on Graduate School Policy, the Committee on Educational Policy, and finally the MIT faculty as a whole, in an unprecedented unanimous vote at the faculty meeting.

Intending to provide better trained managers of technical functions and organizations, the Joint Program plans to remain at pilot size of 10 to 12 students for a second academic year (1982-83), and then to scale up to its full program target of 40 to 50 participants per year. The rigorous curriculum includes an intensive core of analytic subjects taken during the summer with the
Sloan School's accelerated master's program, in-depth studies on the management of technical people and programs, and a related thesis.

Program implementation could not have occurred without the strong and effective collaboration of the Deans' offices in both the School of Engineering and our own School. The substantial financial contributions to curriculum development from Pilkington Brothers Ltd. and the Gillette Company are also deeply appreciated.

The Ph.D. Program

The doctoral program, which prepares the program's participants for academic and related management research careers, experienced another successful year in recruiting an incoming class of highly qualified men and women. A record number of 216 applications were received for fall 1980 admission, a substantial increase over the level of 160-70 experienced in each of the previous four years. Admission was offered to 34 applicants and 19 entered the program in September, a "yield" rate (entrants : admissions) typical of that realized over the past decade. The entering class included four women and eight citizens from foreign countries.

The major fields of the entering class of 19 were distributed as follows: Accounting and Control -- one, Applied Economics -- four, Finance -- two, Health Care Management -- one, Industrial Relations -- two, International Management -- two, Management Information Systems -- two, Management of Technological Innovation -- one, Marketing -- one, Operations Research -- one, Organization Studies -- one, and System Dynamics -- one.

A major shift that has occurred in recent years has been the growth in the proportion of applicants from outside the US. The foreign share of all applications has increased from around 40 percent in 1970 to 67 percent in 1980. A similar trend has been reported by several other leading US management schools.

For a number of years, the median time to complete the doctoral program at the Sloan School has been four years and about 80 percent of the program's graduates pursue academic careers. In 1980-81, six doctorates were granted in Management. The small number of Ph.D. recipients is primarily a reflection of the fact that only nine new students entered the program in 1977. All six of those receiving their doctorates in 1980-81 assumed academic positions at one or another of the following institutions: Asian Institute of Technology (Bangkok), Case Western Reserve University, Simmons College, University of Alberta, University of Michigan, and University of Pennsylvania.

The Ph.D. Committee, chaired by Professor Alvin J. Silk, faces two difficult and interrelated problems. On the one hand, just maintaining the long-established size of the program (20 new students per year) has proved difficult in the face of stiff competition from other management schools which are able to make more attractive financial awards to prospective students. On the other hand, since the incoming class of 20 students is distributed across 12 different major fields, many areas lack a critical mass of doctoral students and are unable to offer doctoral-level subjects and seminars. Demand for Ph.D's to staff the faculties of management schools, here and abroad, continues to outstrip the available supply. Progress, however, is being made in expanding the program's resources and these efforts will continue.

Alfred P. Sloan Fellows Program

On June 1, 1981, 55 Alfred P. Sloan Fellows were awarded the degree of Master of Science in Management. The Class of 1981 reflected a broad diversity of backgrounds and interests, and again was drawn from organizations from the United States and abroad. The Sloan Fellows Program was the first executive education program in the United States, and in 1981 we marked the 50th anniversary of the program with a special dinner for the Fellows to which President Paul E. Gray brought his warmly received salutations.
A comparison of the Class of 1980-81 with previous classes follows:

<table>
<thead>
<tr>
<th>Industry</th>
<th>74-75</th>
<th>75-76</th>
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<td>25</td>
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<td>14</td>
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<table>
<thead>
<tr>
<th>Government</th>
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<tbody>
<tr>
<td>United States</td>
<td>11</td>
<td>11</td>
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The demand for the Program continues to be strong and the quality of the nominations is extremely high. On June 19, 1981, the Class of 1981-82 arrived; there will be 57 participants in the 1981 program. Countries represented in the program are: Australia, Canada, India, Italy, Jamaica, Japan, Korea, Malaysia, Nigeria, and the United Kingdom.

The director of the Sloan Fellows Program, Alan F. White, is an alumnus of the program (Class of 1971) and performed in his accustomed efficient and effective manner. Professor Eli Shapiro served once again as chairman of the faculty program committee but will relinquish this role next year to Professor Arnoldo C. Hax. Professor Shapiro, who has decided to work half-time until his retirement a few years hence, has provided many years of enthusiastic faculty leadership for this important program which continues as the exemplar of its type in the world.

Health Management Executive Development Program

The sixth year of operations was completed by the Health Management Executive Program as an integral part of the Alfred P. Sloan Fellows Program. There were two Sloan Fellows from the medical field: Suzanne C. Friedley, Executive Director, Visiting Nurse Association of Greater Salem, Inc., Salem, Massachusetts, and William H. Straub, Director of Radiology, Department of Radiology, Midland Hospital Center, Midland, Michigan.

Oversights of the special aspects of this portion of the Sloan Fellows Program were shared by Professor Roberts and Mr. White.

Program for Senior Executives

The year 1980-81 marked the 25th year for the MIT Program for Senior Executives. As in the case of the Sloan Fellows anniversary, the School celebrated this special event with a notable dinner at which Howard W. Johnson, Chairman of the MIT Corporation and "father" of the program, reminisced with great feeling about the times and circumstances which prompted the inception of this outstanding executive program. There are now over 1,300 alumni/ae of the program who occupy positions of leadership in many companies and organizations around the world.

The 60 men and women who attended the 50th and 51st sessions in 1980-81 were drawn primarily from United States private industry with approximately 20 percent of the participants coming from abroad. The countries represented were: Malaysia (1), United Kingdom (2), Germany (2), Indonesia (1), Japan (2), Australia (1), Saudi Arabia (1), Canada (1), Austria (1), and Switzerland (1). Demand for the limited number of spaces in the program remains high.
Professor Hax served as chairman of the program's faculty committee and Dr. H. Scott Duncan continued as program director. Both worked hard and well at the planning and execution of this important residential general management program offered for senior managers.

Greater Boston Executive Program

The Greater Boston Executive Program (GBEP) marked its 24th year of operation: one year short of the quarter century mark. It ran from January 30 to May 8, 1981. There were 19 participants representing 13 corporations and the Commonwealth of Massachusetts.

Last year's addition of two senior members of the Massachusetts High Technology Council to the Administrative Committee produced two participants from high technology firms, Analog Devices and Alpha Industries, Inc.

The Alumni Reunion on May 5, 1981, as in the past, was very well attended; George S. Kariotis, Secretary of Economic Development and Manpower Affairs, Commonwealth of Massachusetts, was the principal speaker.

Summer Programs

Sloan School faculty offered 11 Special Programs in the 1980 MIT Summer Session which continued to attract large numbers of professional men and women in management eager to keep up with new developments and techniques in the fields covered.

A two-week program on Management of Research, Development, and Technology-Based Innovation, and a one-week program on The Dynamics of Health Service Systems; Strategic Planning for Complex Health Organizations were offered under the direction of Professor Roberts. In both programs he was assisted by other members of the Sloan School, including Professors Allen, Eric A. von Hippel, Ralph Katz, Glen L. Urban, Richard Beckhard, Finkelstein, and Dr. John F. Rockart.

Professor John D. W. Morecroft and other members of the Systems Dynamics Group conducted the two-week program on Corporate and Economic Policy: The System Dynamics Approach.


The Management Science Group was responsible for four one-week programs: Project Design for EDP Applications (Professor Robert M. Alloway); Key Aspects of Information Systems Technologies: Database Systems, Telecommunications, and Performance Evaluation (Professors John J. Donovan and Stuart E. Madnick); Management Control Systems (Dr. Morris McInnes); and Strategic Planning Systems (Professor Hax). Professor Michael S. Scott Morton, Professor Michael F. van Breda, and Dr. Rockart worked with Dr. McInnes on the management control systems program; Professor Scott Morton also participated with Professor Hax in the strategic planning systems program, as did Walker Lewis, founder and president of Strategic Planning Associates.

Professor Jeremy F. Shapiro, a member of the School's Management Science Group and co-director of the MIT Operations Research Center, was responsible for two of the programs offered. He and Professor Eduardo M. Modiano from the Economics Department of the Catholic University of Rio de Janeiro shared the lectures in Energy Planning Models; William D. Northup, research associate in the Center for Computational Research in Economics and Management Sciences, and Paul S. Bender, director of Resource Allocation Systems at International Paper Company, assisted Professor Shapiro in presentations for the second special program, Resource Management: An Expanded Scope for Logistics.

In addition to these programs offered as part of the Institute's Special Summer Program, several members of the faculty and staff directed and participated in three other summer seminars. The School's Center for Information Systems Research offered its fifth annual summer seminar -- Current Issues in Information Systems: Repositioning the Information Systems Function -- at
the Hyatt Regency Hotel in Cambridge. Professor J. D. Nyhart, who holds dual appointments in the Sloan School and Department of Ocean Engineering, participated in the seventh Harvard Law-MIT Ocean Uses Seminar. Professor Gary L. Lilien and Professor Jean-Marie Choffray of the Marketing Science Department at ESSEC, France, co-directed a three-day seminar in Paris entitled Marketing Science: An International Perspective. Professors Richard P. Bagozzi, John D. C. Little, Silk, and Urban also went to Paris to conduct sessions in this seminar.

Industrial Liaison Symposia

Five of the Industrial Liaison Symposia this past year were directed by Sloan School faculty. Institute Professor Franco Modigliani was the chairman of a one-day program in October -- Criteria for Investment Decisions in a World of High Inflation. In November, Professor Roberts conducted a one-day program in Palo Alto, California, on the Management of Research, Development and Technology-Based Innovation. Adjunct Professor Benjamin C. Ball, Jr., chaired a one-day program in March, Current Challenges in Conventional Fossil Energy Supply. Also in March Dr. Rockart led a one-day program on Current Issues in Information Systems. Professor Edwin Kuh, who is also the director of the School’s Center for Computational Research in Economics and Management Science, was the chairman of a one-day program, Regression and Model Diagnostics, held in May.

These special summer and liaison programs continue to serve an important dual role. They offer specific post-experience training to professional managers and consultants, and they continue to serve the equally important function of helping the School’s faculty make substantial improvements in our year-round degree and residential programs by serving as a "proving ground" for curriculum review, 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 -- almost $2.4 million during fiscal year 1981 -- and continues to show every sign of growing as Sloan faculty participation in many of the Institute’s interdepartmental research centers grows in both leadership and research significance.

This section summarizes the major research efforts and accomplishments of the School. It does not include specific references to the substantial research efforts described in separate center reports. 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. The faculty of the Organization Studies Group is engaged in several projects designed to illuminate the relationship between various organizational variables, the effectiveness and innovativeness of organizations and groups, and the satisfaction of individual employees throughout their careers.

One major focus of this research is organizational culture -- its origins and effects. Professors Beckhard and Edgar H. Schein have launched a project studying the issues in the family firm -- how it begins, how the culture of the organization is established through the actions of the founder
and other key managers, and what issues arise for the family as the firm matures. Professor Beckhard organized a conference of some of the major families who operate businesses in North and South America to begin to identify the crucial issues in this area.

Professors Lotte L. Bailyn, John E. Van Maanen, and Schein are continuing their research on socialization and careers. They have launched a three-year study to investigate first how organizational culture affects the different patterns of socialization of new employees, and then to determine how those different socialization patterns affect 1) organizational effectiveness, 2) individual innovativeness, and 3) life/career satisfaction throughout the career. They are developing methods of studying organizational culture by supplementing traditional ethnographic methods with focused observation, clinical interviews, and formal rating scales for the analysis of organizational documents such as annual reports and orientation booklets. Organizational culture has become a central variable in much management analysis because of the growing interest in the comparison of US and other systems of management. Following his sabbatical in Europe, Professor Schein plans now to formulate some of the systematic differences between management styles in different countries.

Professor Bailyn is concentrating on the study of technically based organizations, attempting to relate the nature of technical work to the kinds of careers which different scientists and engineers pursue. This project builds on previous extensive analysis of technical careers carried out with alumni/ae and now focuses more on several specific organizations where work and culture can be assessed.

Professor Van Maanen is continuing to study selected occupations and organizations by means of ethnographic methods and is working out the various applications of this method to the study of occupational communities both outside and inside organizations.

Professor Schein has also continued to work on the concept of career anchors by conducting systematic follow-ups of alumni/ae of the Sloan School Master's and Sloan Fellows Programs. A method for self-diagnosing career anchors as an aid to career management on the part of the individual, and a method of diagnosing the components of a total human resource system by senior management of organizations, are two concrete outputs of this project.

The process of innovation (versus conformity or adaptation) is also being explored in individuals and groups by Professor Allen and Dr. Katz. Using a large number of Research and Development (R&D) groups in several organizations, they have developed measures of job longevity and group longevity, the length of time an individual has been in the same job or a group has been together, and have related this variable to productivity and innovativeness. As expected from prior research by Dr. Katz, the relationship is curvilinear with innovativeness being lowest both in the beginning during a period of learning and socialization and after a number of years when the individual or group has become "adapted."

Also on the theme of innovation is Dr. Edwin C. Nevis's project on "blocks to creativity," the exploration of a series of individual and group exercises which help individuals and groups to break out of old sets and develop new ideas, and Professor Leo B. Moore's work on innovation in organizations.

All of these research results continue to feed into the study of planned change and organization development. All of the members of the group are developing methodologies for working with organizations to help them to improve their human resource management toward increasing effectiveness and innovation.

Employment and Industrial Relations. A number of important personnel changes took place this year. Professor Emeritus Charles A. Myers, who has given superb service on a continuing basis, especially teaching the Labor-Management Relations subject in the Sloan Fellows Program, has "really" retired. Also, Stanley M. Jacks retired as Senior Lecturer after many years of devoted service to the School. On the other side of the ledger, we have added Professors Thomas A. Kochan and Robert B. McKersie, who have come from Cornell University, and Assistant Professor Katharine G. Abraham joined us from Harvard University where she worked on her Ph.D. in labor economics. Professor McKersie is the former Dean at the New York State School of Industrial and Labor Relations, and Professor Kochan served as senior staff member in the US Department of Labor prior to his arrival at the School.
One of the main Section activities this past year has involved program development at both the master's and doctoral levels. Under the leadership of Professor Kochan, a proposal has been prepared for strengthening the curriculum of the Ph.D. concentration in Industrial Relations. A number of specialized subjects in collective bargaining and human resource management will be developed over the next year (some in coordination with the Organizational Studies Group) and one of the subjects on theory has already been offered.

At the master's level discussions have been taking place about expanding the work in the human resource area and in conjunction with a student-initiated interest group, called the Human Resource Society, the faculty of the Section has been giving consideration to more course work and more emphasis on this important and rapidly developing area of business management.

It is also significant to note that the undergraduate subject, 14.63 Labor in Industrial Society, has been reintroduced into the distribution requirements of the Humanities Department at MIT. It is clear that the Section can continue to play an important role in the presentation of course work on industrial relations and human resource subjects for the larger MIT community.

With respect to research, the Tuesday workshop continued in a very active fashion and some sessions draw upwards of 50 to 60 participants. This series plays an important role in bringing together scholars from around the Boston area, as well as graduate students and faculty members from various departments at MIT.

On the research front, the main interest of the faculty members in the Section on a "corporate" basis was directed towards the preparation of a comprehensive proposal for the Sloan Foundation. We hope to receive a start-up grant this summer and would then submit a formal proposal this fall for a three-year grant. This would enable a number of faculty members and graduate students in the Section to investigate the adaptability and potential of the US system of collective bargaining. Professor Kochan will be the principal investigator for this major undertaking.

He also has been working under a contract with the Occupational Safety and Health Administration (OSHA) to develop a framework for assessing the effectiveness of joint labor-management safety and health committees in the Federal sector. Base line data have been collected from a large sample of committees in the Tennessee Valley Authority.

Professor Kochan has authored many articles that appeared this past year. One of the most interesting involves an analysis of the mediation process pursued by former Secretary of State Henry Kissinger in the Middle East and has appeared in a book entitled Dynamics of Third Party Intervention.

Professor Kochan's book, Collective Bargaining and Industrial Relations, published in spring 1981, has received enthusiastic reviews. A future issue of a major professional journal, Industrial Relations, will carry a symposium devoted to a commentary on the book. A number of distinguished people will be preparing articles including Clark Kerr, Orley Ashenfelter, and Milton Derber.

Professor Kochan's role as an editor has expanded; he has been invited to join the editorial board of Industrial Relations and is continuing to work as chief editor for a 1982 research volume of the Industrial Relations Research Association entitled "Industrial Relations Research in the 1970s: A Critical Appraisal."

Professor Phyllis A. Wallace continues to carry on an active program of research. She has continued her survey of graduates from the Classes of 1975 through 1979 of the master's program of the Sloan School. This past year the project concentrated on follow-up responses from the Class of 1975 (a five-year tally). An important by-product of the research has been an assessment of the Sloan School curriculum. It has become clear that the graduates are calling for more subjects to help them with communication skills and more knowledge that would lead to some of their entrepreneurial career objectives.

Professor Wallace continues with a long-standing interest on women in the work place, and is finishing a manuscript on this subject. Her important publication, Black Women in the Labor Force, was published last September by MIT Press.

Professor McKersie has devoted most of his research time this past year to the industrial relations dimensions of "reindustrialization." He coauthored a report on large-scale work force displacements...
Professor McKersie has been working for the past several months on a study for the Committee for Economic Development dealing with the subject of productivity and how it is affected by institutional arrangements in the industrial relations and personnel field.

Professor Thomas A. Barocci has taken the lead in a research project on quality control and human resources. Raising funds from several companies affiliated with the Industrial Liaison Program and using students working in a coordinated thesis workshop, Professor Barocci has been isolating and determining the effects of different human resource management techniques on quality and productivity within several high technology companies. Following a long-standing interest in employment and training programs, Professor Barocci has been preparing a manuscript that will summarize the state of knowledge about these programs. His work will be an important evaluation of this phase of employment and training history.

Two of Professor Barocci's publications are worthy of special note. His book, entitled *Non-Profit Hospitals: Their Structure, Human Resources and Economic Importance*, was published early this year and an article on collective bargaining among US physicians has appeared in a symposium on industrial relations and the health services.

Professor James W. Driscoll continued his analysis of the impact of the Scanlon Plan on workers, management, labor organizations, and collective bargaining. He has gathered data at seven Scanlon Plans and matched them with seven non-Scanlon Plan companies. He made a report on his preliminary research findings to the biannual Scanlon Plan Conference held at MIT.

In addition, Professor Driscoll is continuing his work on the impacts of office automation, particularly the social costs of the new technology to occupational safety and health, quality of work life, and unemployment. He is particularly interested in assessing the impact of automation for productivity and organizational effectiveness.

Professor Abraham is completing her research work analyzing the relationship between job vacancies and unemployment in the US economy. The results indicate that at most points in the business cycle the number of unemployed people is much larger than the number of vacant jobs. A second preliminary finding is that in many developed countries, the job vacancy rate associated with any given unemployment rate seems to have been larger in recent years than was the case prior to 1970. The reasons for this shift are being examined.

She has also been interested in the relationship between seniority, compensation, promotion, and termination policies in US companies. Based on a review of considerable evidence she and her colleague, Professor James Medoff of Harvard, have found that junior employees tend to be underpaid relative to the value of their current contributions, while senior employees tend to be paid more than the value of their current contributions.

Professor Katz has been analyzing changes that occurred in the racial composition of students and faculty in large urban school systems between 1968 and 1976. He also is playing a key role in a larger MIT project called The World Auto, co-directed by Professors Alan A. Altshuler and Daniel Roos. He is responsible for the labor relations facets of this ongoing project.

Two members of the Department of Economics continue to play key roles in the work of the Industrial Relations Section. Professor Henry S. Farber has been doing work on alternative non-strike mechanisms for settling labor disputes and assessing the effectiveness of various outcomes. Specifically, he is interested in the effect of various arbitration schemes on the outcomes of the collective bargaining process. He also has been doing empirical work on wage indexation and negotiated wage changes and has been examining several hundred contracts for the period 1954 to 1973. Another ongoing interest is the relationship between seniority and labor turnover and some theoretical work on estimating union versus nonunion earning functions. Quite significantly, research support for Professor Farber has been received from the National Science Foundation, and more recently he has been named a Sloan Research Fellow by the Alfred P. Sloan Foundation for the period September 1981 through August 1983. This is, indeed, a very important recognition.
Professor Michael J. Piore has been investigating the sweatshop and industrial home work industries and their relationship to undocumented migration. The work is based largely on interviews with employers, workers, union and government officials as well as a sample of Spanish-surnamed union members.

Professor Piore has continued his interest in comparative industrial relations and has been examining the way in which the French government approves economic layoffs in France and the dispersion of factory employment in Italy. These themes are part of his larger interest in unemployment, inflation, growth, and labor-management relations in western European countries.

This year Professor Piore was honored by being appointed to the Mitsui Chair in Problems in Contemporary Technology.

In closing it would be appropriate to cite a number of extracurricular activities that illustrate the wide range of involvement by Industrial Relations Section members.

Professor Abraham appeared on the television program "Miller's Court" as an expert for a discussion on age discrimination. Professor McKersie authored an article that appeared in The Boston Globe dealing with the employment consequences of Proposition 2 1. Professor Wallace has been involved in a wide range of local activities serving as a director for the State Street Bank and the Stop & Shop Companies. In addition, she was recognized by the minority community at MIT in receiving the Martin Luther King, Jr., Achievement Award for distinguished service in education this past year.

Finally, in terms of service, the Scanlon Plan Conference held in October 1980, with 450 participants, represented one of the key outreach activities of the Section. This conference brings together key employer and union representatives of companies with Scanlon Plans and representatives from organizations interested in learning more about Scanlon Plans.

Economics and Finance

The Economics and Finance Group is the second basic disciplinary area on which the School's teaching programs are built and whose research contributes to the understanding of important theoretical and practical problems relating economic and financial considerations to management concerns.

On the theoretical and modeling fronts, Professors Kuh and Ernst R. Berndt continue their work in careful examination of data sources and data construction procedures.

Professor Kuh continues to serve as director of the Center for Computational Research in Economics and Management Science. He has continued to work on ways to understand the essential aspects of econometric model behavior. While complete econometric models in theory are complex but turn out in practice to be much less so, it is possible through sensitivity analysis and eigen analysis to isolate parameters, exogenous variables, and equations. A related set of issues concerns regression diagnostics, in particular finding data points which are different from the bulk of the data and which exert disproportionate influence on estimated coefficients. A book on initial work in this area, coauthored by Professor Roy E. Weisch and Visiting Professor David A. Belsley, entitled Regression Diagnostics, was published by John Wiley and Sons in June 1980.

Professor Berndt's research, supported in part by the National Science Foundation (NSF) and the Department of Energy, concentrated on a number of topics, including 1) short-run increasing returns to labor, 2) economic measures of capital and capacity utilization, 3) effects of increased energy prices on the market value of capital equipment already in place, 4) productivity measurement using data from the securities market to evaluate capital services, and 5) an historical paper on the energy theories of value.

Professor Julio J. Rotemberg completed an analysis of the consequences for aggregate economic activity of the perception on the part of firms that changing prices is costly. He has shown that US data are consistent with this hypothesis. Professor Rotemberg also has studied the use of information criteria for econometric model selection using out-of-sample data. He has also worked on the empirical distinction between the hypothesis that only the unanticipated component of the changes in the money stock and the hypothesis that both the unanticipated and anticipated components affect aggregate output.
Professor Thomas M. Stoker's principal research areas were aggregation theory and consumer demand analysis. He revised a paper which studies the use of survey data in characterizing macroeconomic relations and it was accepted for publication in the *Journal of the American Statistical Association*. He completed a paper in which he has formulated and solved the aggregation problem, which revealed several fallacies in interpreting estimated macroeconomic functions. Currently he is developing empirical techniques to study aggregation issues and plans to apply them in studying the consumption function and aggregate production functions. Professor Stoker also continued work on two micro-macro models of demand with D. Jorgenson and L. Lau. The estimation of a model of overall personal consumption expenditure was completed, with the model embodying all tenets of classical utility maximization by individual families.

Professor Richard L. Schmalensee continued his research on industrial organization and government regulation. During the year he completed a theoretical paper on the sources of demand advantages enjoyed by pioneering products and wrote on equity issues raised by competitive pricing under imperfect information, focusing on pricing insurance. In addition, he studied product safety regulation and the profit and welfare implications of bundled pricing by firms with market power. Finally, he was coauthor of a paper on the implications of non-convexities for the optimal use of renewable resources.

Professor Robert S. Pindyck has worked on both theoretical and empirical issues in natural resource economics, including the characteristics of optimal patterns of resource exploration, the effects of various kinds of uncertainty on prices and production rates in both nonrenewable and renewable resource markets. Professor Pindyck has also been interested in the macroeconomic impact of rising energy prices and, in particular, the ways in which energy prices affect economic growth, inflation, and unemployment.

Professor Paul R. Krugman has been working on the international aspects of energy policy. The research focuses on two questions. First, what are the balance of payments and exchange rate implications of changes in oil prices? The crucial point here is that the direct balance of payments burden of higher oil prices may be more than offset by the indirect balance of payments benefits of OPEC spending and investment. Second, the research examines international interdependence in energy policy. Are other oil importers hurt or helped by, say, US oil decontrol? Again, these are two opposing effects. On one hand, reduced imports by the US depress the world price of oil, helping other importers. On the other hand, by reducing oil imports, the US improves its terms of trade at the expense of other oil importing countries. To answer these questions, Professor Krugman has been developing and simulating simple, aggregated three-region models of international trade and investment.

Professor Lester C. Thurow worked on the causes of the country's productivity decline in recent years and on proposals for cures. He continues at the same time to contribute widely to popular discourse on these and other economic issues through his contributions to national debate in the public press and television both in the US and abroad.

Professor Carliss Y. Baldwin's principal research continues to be in the allocation of human and financial capital (resources) within a corporation, industry, or economy. The main areas of investigation are: 1) optimal investment in long-lived assets when future opportunities are unknown; 2) optimal investment policies for participants in imperfect markets; and 3) design of appropriate financial incentives to induce private investment in public projects.

Professor Fischer Black has completed a working paper suggesting that society might gain by replacing taxes on income with taxes on spending, especially when we take the welfare of future generations into account. It is even possible that the best mix of income and spending taxes involves a subsidy to income combined with a relatively high tax on spending. He is continuing to study business cycles, taking them to be a natural result of freely operating markets for goods and services and for capital and labor. He is also working on his theory of earnings, which suggests that a firm's earnings are (and should be) more a measure of value than of change in value.

Professor Daniel M. Holland has continued his joint research with Professor Stewart C. Myers on corporate profitability and costs. They have revised the estimates prepared for the Committee for Economic Development study (published in 1979) and in their paper in the May 1980 *American Economic Review* to take account of benchmark revisions in the National Income Accounts. Also, they are improving their estimates of the return to investors, particularly with respect to holdings of corporate stock.
Their earlier findings stand up in the face of the new estimates, namely:

- Over the whole of the post-war period, there has been no trend in corporate profitability -- the rate of return earned on plant, equipment, and inventory of all non-financial corporations and the manufacturing subsector thereof. What appears to be a declining trend when time alone is considered disappears when we take account of other factors affecting profitability -- the level of economic activity and (for after-tax returns) the pace of inflation. This is true both of rates of return before tax and rates of return after allowing for corporate tax.

- The effective rate of tax on operating income (profits plus net interest paid by corporations) has drifted downward since the war, more sharply for all non-financial corporations than for the manufacturing subsector.

- The rate of return earned by investors on their portfolio of stocks and bonds of all non-financial corporations and manufacturing corporations have been much more volatile than the rate of return earned on corporate physical capital, but over the long pull, on average, both rates of return have been the same.

This joint research is the US contribution to an international project organized by MIT’s Program in International Business (a joint activity of the Center for International Studies and the Sloan School) for which researchers in eight other countries -- Japan, the United Kingdom, Italy, Germany, Finland, Sweden, Austria, and Canada -- are undertaking similar studies. Professor Holland has been in charge of this project from its inception in 1974.

There have already been four conferences, and the project has ended with a final meeting in Cambridge, sponsored by the Lincoln Institute of Land Policy Studies in June 1981. The papers are expected to be published in a book. Professor Holland will be responsible for editing that volume and preparing a summary evaluation chapter.

Together with Professor Oliver Oldman of the Harvard Law School, Professor Holland has been working on a paper for CIAT, a group of North, Central, and South American tax administrators, on measuring tax evasion. They presented a paper on this topic to this same group 10 years ago, and have been asked to bring them up to date on what has happened since. The proceedings of this conference will be published by CIAT.

Professor Holland has recently joined Professor Lawrence E. Susskind’s project on monitoring Proposition 24. Work on this project is in the design stage. At present, his primary responsibility is to be available for research advice and guidance to those who will be gathering the basic data this summer. He may, however, take up a specific area of the project later.

Professor Donald R. Lessard continued his research on actual and potential risk sharing through international capital markets by less developed countries (LDCs) with research papers on the impact of "country" risk on international capital flows and on the relationship between the level and pattern of external financing and the scale and timing of energy exploration and development in LDCs.

He undertook a major study of financial incentives provided by the government to firms under the guise of employment creation (with Professors Baldwin of MIT and Scott Mason of Harvard). Methods were developed for estimating for "cash grant equivalents" of various incentive measures and for integrating the private and budgetary analyses of these measures with existing frameworks for social cost/benefit analysis.

Professor Lessard continued his research on international portfolio investment with an investigation of the impact of currency movement on stock prices (with Professor Rene Stulz of the University of Rochester) and of the relationships between stock prices and inflation (with Professor Richard Cohn of the University of Illinois at Chicago).

Professor Terry A. Marsh is in the process of developing three papers from his dissertation on equilibrium asset pricing and the term structure of interest rates. He has completed a paper (joint with P. Brown and A. Kleidon) which has been submitted for publication, and commenced two joint research studies, with R. I. Webb, of market microstructure and differential information speculation in futures markets. He has also commenced a paper, with A. Madansky, which is concerned with factor analysis of stock prices and interest rates.
Professor Robert C. Merton has continued his research in finance and economics in the areas of capital markets, information evaluation, asset and corporate liabilities pricing. New areas of research undertaken include a theoretical analysis for the role of a Social Security type "pay-as-you-go" pension system; integration of private and public pension systems and distortions of various tax systems. He has become involved in a joint research study with Professor Robert K. Merton, the sociologist, to develop a formal mathematical model of the reward system for scientific research and to analyze the effect this system has on problem choice. His research has been supported in part by both the National Science Foundation and the National Bureau of Economic Research.

Professor Modigliani's main research activity this year has been devoted to a fresh look at the nature of the monetary mechanism and its implications for stabilization policies. The research is supported by a two-year NSF grant. In addition, he has continued to pursue his long-lasting interest in the determinants of aggregate saving, and especially the role of social security. A third research interest has been the determinants of the role of inertia and demand and supply shocks in controlling the path of inflation in general and in the US in particular. Finally, he has continued to give some attention to the effects of inflation on the economy and on financial markets in particular. These interests have been discussed in lectures in universities around the country, as well as at the University of Paris and the University of Bergamo.

Professor Modigliani continues to serve as vice president of the International Economic Association, and is president of the American Finance Association.

Professor Myers has continued research in several different areas. He completed work on a paper evaluating rate of return regulation of property and casualty insurance and also a more general paper on how inflation should be incorporated in regulatory decisions. He completed a paper on stock issues and investment policy with differential information, and continued work with Professor Holland on measuring profitability and capital costs of US corporations. He also began a study on the potential role of futures contracts on stock market indices.

Professor Richard S. Ruback completed a paper entitled "The Effects of Discretionary Price Control Decisions on Equity Values," which explores the changes in equity values associated with regulatory decisions during Phase II of Nixon's Economic Stabilization Program. This paper has been conditionally accepted for publication in the *Journal of Financial Economics*. In addition, a paper coauthored with Kenneth French and G. William Schwert entitled "Effects of Nominal Contracts on Stock Returns" was completed and presented at the National Bureau of Economic Research Conference on Inflation and Financial Markets. This paper estimates the effects of unexpected inflation on the returns of the common stock of companies with different monetary positions and different amounts of nominal tax shields. A first draft of a paper entitled "Assessing Competition in the Market for Corporate Acquisitions" was recently completed. This paper defines two forms of rivalry in this market and presents a method to assess the degree of competition. He is also currently investigating (with Ronald Schmidt) the impact of electric utility rate cases on the equity values of the companies involved.

**Management Science**

The Management Science Group, the third of the Sloan School's principal foci of teaching and research, 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.

In marketing Professor John D. C. Little is developing and calibrating models of customer behavior using new large-scale data sources spun off from point-of-sale recording devices. He and Professor Silk are also completing the analysis of an ambitious controlled experiment that measures the relative effectiveness of two marketing programs with unprecedented accuracy. Following his long-standing work on new product development, Professor Urban has started a new line of research to construct models for overall marketing strategy. Professor Bagozzi has developed theories and related measurements that look deeply into the conceptual structure of attitude formation and its impact on intentions and behavior. Opening up a previously unexplored area, Professor
John R. Hauser has formulated a theory of defensive strategy against new market entry. Professor Lilien continues his pioneering work on models to describe industrial marketing processes.

The invasion of US markets by high-quality, low-cost foreign goods has brought an urgent new concern to the issues of operations management and corporate strategy for manufacturing concerns. Professor Hax has built an extensive conceptual and empirical foundation for the design and implementation of formal strategic planning systems. Professor Graves is working on theory and applications in production-inventory systems, including issues relating to the design and control of industrial robots. In conjunction with Professor Hax, Professor Bitran has been examining major issues in hierarchical production planning. Senior Lecturer Harlan C. Meal has developed a simulator for studying the parts fabrication and assembly stages of a multistage production process.

Accounting and control, central to the management of any organization, are undergoing changes as new technology and knowledge unfold. Dr. McInnes is investigating the corporate use of computer models in financial control processes. Using the results of experiments and field measurements, Professor Peter Brownell has completed a study of the relationship between budgetary participation and organizational effectiveness. On the theoretical side, Professor Ram T. S. Ramakrishnan is extending agency theory to examine a variety of issues involving risk and imperfect information among multiple individuals in an organization. Professor H. David Sherman is developing and applying the new methodology of data envelopment analysis to evaluate the relative efficiency of nonprofit organizations where multiple inputs and outputs need to be considered simultaneously. Professor van Breda has examined accounting rates of return under inflation, a topic of high current interest.

The computer revolution rolls onward, affecting management through its impact on information systems. Professor Madnick's basic research on database computers seeks to extend their capabilities by orders of magnitude. Dr. Rockart, director of the Center for Information Systems Research, has studied top executives' information systems and finds an increasing number are fitting into a common pattern that includes an information support database, user-tailored access methods, consulting support within the organization, and, perhaps most interesting, the user as a designer. The field of decision support systems, an outgrowth of the pioneering work of Professors Scott Morton and Peter G. W. Keen, continues to expand and deepen. Professor Keen is currently working on a value analysis methodology for such systems. Professor M. Lynne Markus is studying political and organizational factors in the success of information systems implementation. The experimental research of Professor Ghani shows the desirability of computer graphics for problem solving by managers. Professor Hoo-min Toong's analytic and simulation models of multi-processor systems have demonstrated the efficacy of certain key design concepts, expected to affect the next generation of office systems. In Professor Donovan's work on information system methodologies, he has focused broadly on design, evaluation, and implementation.

Energy policy issues continue to command American and world-wide attention. Professor Henry D. Jacoby, associate director of the Energy Laboratory and director of its International Energy Studies Program, has investigated world uranium markets in depth and finds, among other things, that they are softening. Professor Gordon M. Kaufman continues his innovative, disaggregated approach to oil and gas supply and has undertaken an energy policy study for the World Bank.

Professor Arnold I. Barnett is active in public policy research, particularly in relation to crime and public safety statistics. His airline safety and homicide probability studies have been picked up by local and national media.

Less conspicuous to laymen and to managers, as well, is the methodological underpinning of management science research. Statistical methods and optimization techniques pervade many applications. Professor Roy E. Welsch has been pioneering the important field of regression diagnostics with his colleagues, Professors Kuh and Belsley. Their methods are finding rapid dissemination, in part because they have been incorporated into TROLL and other statistical software. Professor M. Anthony Wong's research on clustering methods is finding application in information systems analysis. In the optimization area Professor Jeremy Shapiro is active in theoretical and empirical research on why some members of a family of integer programming problems can be orders of magnitude more difficult than others that are closely related. Professor James B. Orlin's research on algorithm development and heuristic analysis has resulted in efficient solution techniques for several classes of problems previously considered poorly solved. In a continuing effort Professor
Thomas L. Magnanti is doing research on networks, including the impact of formulation on solution methods, the analysis of probabilistic elements, and the modeling of equilibrium problems.

System Dynamics

Over the last year, participation in the System Dynamics National Model Project has expanded to include a number of energy companies, and a total of nearly 40 sponsors representing corporations, foundations, and private individuals. The group has worked with two main versions of the National Model, one addressing inflation and the long wave in economic activity, and the other addressing energy policy issues.

In the area of inflation, this work suggests that inflation arises primarily from monetary factors. In particular, the principal sources of inflation appear to be Treasury deficit financing through the Federal Reserve, known as "monetization of the debt," and rising money velocity due to changes in financial transactions technologies and banking regulations that enable corporations and households to conduct transactions with smaller average balances in relation to the dollar rate of transactions. Treasury deficit financing through the Federal Reserve increases the money supply in such a way that bank reserves are increased by the same amount. In turn, the increased reserves allow a several-fold further increase in money as a consequence of loans made by commercial banks. As prices rise due to increased monetary purchasing power, the value of assets increases, and permissible debt levels based on assets rise in tandem, thereby generating demand for credit to absorb available borrowing capacity. Thus, the portion of the Federal deficit that is financed through money expansion appears to contribute directly to inflation with relatively minor impact on real economic activity, meaning real GNP, employment, and unemployment.

Rising money velocity raises the nominal purchasing power of a given money supply and like more money, thereby puts upward pressure on prices. Many corporations are today operating with two to four times the transaction rate of a decade ago, with no higher money balances. Such rise in money velocity represents a significant contribution to inflation.

Closely related to the work on inflation is a beginning examination of "supply-side economics" that underlies many of the tax-reduction proposals of the Reagan Administration. The primary finding here, still preliminary, is that tax reduction before the Federal budget is first balanced will increase inflationary pressures without increasing productive output. A combination of inflation and changes in relative prices can offset the incentive effects of tax reduction for greater work effort and more capital investment. An alternative thrust for supply-side policy is to attempt to move labor out of overhead activities in government and the corporate sector and into direct production of goods and services. In this sense, reduced government expenditure and employment should be adopted as the primary policy to enhance the supply side of the economy. At the same time, a tight money policy can restrain inflation while enforcing a reduction of overhead costs in the private sector.

Another major area of research on the National Model concerns national policy. There has been some work on special projects for the US Department of Energy and the California State Energy Commission to understand the reciprocal feedback relationships between energy and the economy, in which energy price and availability affect economic variables that in turn influence the future evolution of the energy sector.

Beyond the National Model work, Professor John D. W. Morecroft is seeking to establish an Industrial Dynamics Sponsors Program to promote corporate applications of system dynamics in a variety of policy areas.

Finally, we have continued to develop our teaching programs in system dynamics within the Sloan School. One particularly effective subject has been 15.875 Applications and Implementation of Industrial Dynamics. In this subject, students divide into pairs to work with a local corporation to apply system dynamics modeling over one semester to an area of corporate policy. Over the past year, corporate participants in the subject have included Codex Corporation, International Harvester, Pratt & Whitney Aircraft, and Millipore Corporation.
Significantly expanded teaching activities and an increased faculty research program continued to focus on the effective generation of technological innovation. Both teaching and research concentrate on the longer range technological aspects of corporate development and performance.

Professor Allen has continued his research on technical communications with a study of information flow in the metals industry of Sweden. That work complements domestic studies done in collaboration with Dr. Katz on communications into and within long-range research and development (R&D) groups. Their efforts are now aimed at explaining the "not-invented-here" syndrome and its effects upon technical obsolescence.

Dr. Katz is also researching engineering supervision in a joint study with Professor Michael Tushman of Columbia University and has an ambitious investigation under way on project management in matrix organizations. Dr. Katz has combined these studies well with his other work on career patterns of young engineers as well as nontraditional professionals.

In her first year at the MIT Sloan School, Professor Dorothy Leonard-Barton has continued her prior research interests in the nature of social and technological diffusion processes. A new research project is examining the acceptance of both radical and incremental innovations among dental specialists, with expected generalizations to other fields.

Professor Roberts has renewed his research studies on technology-based company founding and growth. Three parallel studies gathered data on 60 Massachusetts companies, their entrepreneurs, and managerial processes. Another effort in collaboration with Professor James M. Utterback of the School of Engineering is comparing success factors affecting US technical firms with similar Swedish companies. Professor Roberts has also initiated other research projects on the generation and transfer of health technology.

Professor von Hippel continues his research on the mechanisms by which innovators gain the benefits from their innovations, such as patents, lead time, and know-how. This follows on his earlier research on the role of users in generating innovations, especially in the area of industrial goods.

Expansion of subject offerings began during 1980-81 with Professor Leonard-Barton's new subject on Diffusion of Social and Technological Innovation. Major curriculum development efforts began to develop the several new subjects needed for the newly approved Joint Master’s Degree Program in the Management of Technology. These activities are discussed more fully in that section of the Dean's Report.

Professor Ching-rui Xu of the People's Republic of China and Professor Paul Roy of Laval University in Quebec contributed to the area activities during the past year as distinguished visitors. Both will extend their visits into the next academic year.

Corporate Strategy, Policy and Planning

Professor Louis L. Banks continues his investigation into the impact of the media on the behavior of firms and on a more philosophical level on the "social values" of firms.

The work of Professor William F. Bottiglia on the philosophy of civilization continues and hopefully will be completed next year. This promises to be a major piece of intellectual work.

Professor Edward H. Bowman's research into the relationship between risk and return continues. In addition, he started looking into the manufacturing strategy of firms, an area which combines his original field of specialization, that of operations management, and strategy.

Professor Mel Horwitch is continuing his work in the area of management of large-scale projects requiring joint action by the public and private sector. He has completed his work on the supersonic transport (SST), and is now focusing on synthetic fuels.

Professor Zenon S. Zannetos continues his long-range research in the areas of: 1) oil economics, 2) ocean transportation, and 3) the theories of the firm and of organizational decision making,
with particular emphasis on the management of complexity. Some major publications are forthcoming on these topics. In addition Professor Zannetos has launched a major research project in industry analysis. The objective is to develop a theory and methodology for industry analysis, as well as measures of productivity and innovation.

International Management

Professor Richard D. Robinson has been involved in the preliminary planning of two major research projects. The first is a study of the Japanese managerial system, how it is changing, and how it impinges on US firms taken over or newly established in the US by Japanese companies. To what extent are the two countries' systems perceived to differ by knowledgeable managers in Japan and the US? How are the two systems perceived as changing? To what extent is it perceived that a transfer of management styles in either direction is possible or desirable?

The study will involve structured interviews of a group of Japanese and US managers in Japan and within the US. There will be no attempt to construct representative or paired samples, but to explore the experience of managers knowledgeable about both systems either through study and/or practice. In the Japanese case, interviews will be conducted with as many of the 80 Japanese Sloan School graduates (masters' degree holders and graduates of the Senior Executive Program) as are available. In addition a group of US managers resident in Japan will be identified and similarly interviewed. All told, the target will be 15-20 interviews in both groups in Japan. In addition, a small group of Japanese and US academicians specializing in management and resident in Japan will be included.

During the following academic year, a group of six Sloan master's students interested in doing dissertations in the area will be selected. They will interview in aggregate approximately 30 Japanese management personnel in the United States. Special attention will be focused on the impact on behavior of US firms which have been taken over or established by Japanese corporations and have been managed to a significant degree by Japanese expatriates.

The second project, for which preliminary work has started, is an investigation of the impact of government incentives (US and foreign) on US corporate decisions to invest abroad. Special attention will be given to investment decisions relating to the lesser developed countries. A sample of some 40 corporations will be drawn from a list of 132 which Professor Robinson studied in 1956-59. The purpose of the project, which is funded by the Overseas Private Investment Corporation (OPIC), is to ascertain the cost-effectiveness of investment promotion programs. This work follows a comparative study completed by Professor Robinson last year for OPIC and the International Division of the Chamber of Commerce of the U.S on the investment promotion programs of 20 developing countries.

Professor Lessard's work in the international area has been described earlier in the discussion of research in the Finance Group.

Health Care Management

The Sloan School's teaching and research interests in health care management continued apace. The Health Management Option of the Sloan Fellows Program continued to attract mid-career health professionals, complementing the shorter health executive programs carried out in the summer session and with the Association of American Medical Colleges. The latter programs actively involved Professors Beckhard and Roberts and Dr. Rockart.

Professor Finkelstein continues to make research progress across a broad front of related studies on the development and dissemination of health technology. With funding from the National Institutes of Health and the Health Care Financing Administration, Dr. Finkelstein has been investigating the impact of clinical trials on physician use of health technology, cost and social impact of health technologies, and the abandonment of established medical technologies. He has been developing a mathematical model to encompass the observed patterns of technology and adoption and use, while also seeking to explain the relationships between biomedical innovation and the utilization of health services.

Professor Roberts has initiated two research studies in the area of emerging health technology. In the first he is studying the generation, use, and transfer of biomedical ideas by clinician-researchers in teaching hospital settings. The second effort, funded by the Kaiser Family
Foundation for the new interdisciplinary Whitaker Program in Health Policy and Management, is studying the commercial development stage of health research results, contrasting the roles of new and older companies in the areas of drugs and medical devices.

Dr. Rockart extended his efforts on issues involving hospital information systems, collaborating with Professor Roberts and Alan Dowling in Dr. Dowling's now-completed doctoral research on the adoption of medical software systems. Dr. Rockart became a member of the Executive Committee of the Whitaker Program in Health Policy and Management, chaired by Professor Roberts.

Efforts by Professors Roberts and Finkelstein last year in convening a major National Institutes of Health-sponsored conference have resulted in an important new book, "Biomedical Innovation," that documents the state-of-the-art of managerial and policy knowledge of the medical innovation process. The book is due to be published by MIT Press in December 1981.

In addition to Dr. Finkelstein's newly introduced subject on Health Technology, major curriculum development efforts are now under way, funded by the Kaiser Family Foundation grant. The Sloan School will be actively involved with the Departments of Economics and Political Science in the new program that will formally be sponsored by the MIT Whitaker College of Health Sciences, Technology, and Management.

Dr. Norman S. Stearns, Associate Dean of the Tufts University School of Medicine, continued as Visiting Professor of Health Management and helped lead the year-long seminar in Health Management as well as providing valuable career counseling to students interested in health-related careers.

EXTERNAL RELATIONS

This administrative area, created almost two years ago, continued to develop relationships with external constituencies (alumni/ae, corporations, and the media) in order to help meet some of the School's objectives.

Leigh Chapman, Manager of Alumni Relations, left the School on October 31, 1980. Shortly thereafter Alice Moriarty was asked to undertake some alumni/ae activities, such as the time-consuming task of locating records and data, and coordinating a number of disparate administrative components within and outside the School.

Dean Peter P. Gil, who was asked initially to assume responsibility for External Relations, devoted most of his time to alumni/ae fund raising, relationships with alumni/ae, and the School's Sponsors Program.

Pamela W. Turner, Director of External Relations, concentrated primarily on corporate and media relations, with additional responsibilities for special assignments dealing with the analysis of financial and facilities needs of the School.

Although Ms. Turner and Dean Gil tended to focus on different aspects of External Relations, there has been more of a team-sharing approach to all of the external relations needs of the School. The sharing of analysis and decision making increasingly includes other administrative elements of the School as well as coordination with MIT's Development Office, the Industrial Liaison Office, and the Alumni Association.

The Sloan Sponsors Program, formally launched in the last quarter of the previous year, has attracted 13 new corporations. The 14 organizations that were already contributing were asked for permission to list them as sponsors and they have agreed. In addition to these 27 organizations, three others are considering our invitation to become members and we expect a formal acceptance in the near future.

This relatively new program has already generated much needed unrestricted income (about $68,000 from new Sponsors this year). Every indication points to a strong potential for continued growth in the future. Follow-up of about 12 invitations already outstanding could increase the number of Sponsors by 25 to 50 percent. The exploration and development of new Sponsors continues as an ongoing activity.
Sponsors have been invited to send one or two representatives to the first Sponsors' meeting on October 12, 1981.

This was the 50th anniversary year of the Sloan Fellows Program, and a Convocation was held on October 2-4 to celebrate the anniversary. The turnout was strong. Some 700 persons attended the various panel and seminar sessions and the post-Convocation feedback was enthusiastic.

The fund-raising efforts of the School continue to produce increasing revenue. The drive to fund fully a Chair in memory of Erwin H. Schell was accomplished. More than $1 million was raised.

The amount of capital accumulated for the Sloan Fellows Chair has increased from $730,000, as of June 1980, to $855,000, as of May 1981. By June 1981 that amount is expected to be approximately $875,000. The move towards the $1 million target has been slow but steady since June 1979 when only $325,000 in capital was available.

Alumni/ae of the School have responded in a strong, encouraging manner to help meet the School's financial needs. The total amount received from all alumni/ae by the end of this fiscal year is estimated at $380,000.*

What may be of even greater importance than the monetary contributions of our alumni/ae is their warm, enthusiastic response to the request for volunteers. There is strong evidence of a large, loyal alumni/ae body "out there" that is anxious to help the School in its current plans to develop an alumni/ae structure that will serve the needs of alumni/ae and of the School. Progress this year has been made in identifying sources of help from the current students and alumni/ae of the graduate management programs.

Other alumni/ae activities included a session in New York City to meet with Harrison Goldin, Comptroller of that city. Some 30 alumni/ae of the various School programs attended. The meeting was organized by Jeffrey Lynn (S.B., Class of 1972; S.M., Class of 1972) and Ms. Chapman (S.M., Class of 1978), and hosted at the Medical School, New York University, by Associate Dean David Scotch (Sloan Fellow, Class of 1977).

Various meetings of the Society of Sloan Fellows were held during the year, including one in Washington, DC, to coincide with the Sloan Fellows Washington field trip. The Society has organized a mini-convocation to take place in Philadelphia on October 2, 1981, to be hosted by the Sun Company.

Efforts to develop media contacts which might provide desirable publicity for the School continue. The number of inquiries received from the media has increased as have our self-initiated contacts with the business press. The School's visibility in the press is largely focused on individual faculty members who are increasingly identified as "MIT management," or, for example, "MIT Professor of Finance" as in the Fortune article on Professor Black's work. This increasing contact is developing an awareness among the press of the unique contributions of MIT's management school.

An effort has been made to coordinate media relations internally within MIT to assure that inquiries received by the MIT News Office are responded to appropriately, and that write-ups appearing in the Industrial Liaison Program's "Report on Research" (which is also distributed to the media) represent new research at the management school.

All of these efforts reflect a conscious strategy to build on MIT's existing professional recognition and visibility in order to project a more far-reaching but accurate image of the School. Efforts to establish direct contact among management faculty/administration and members of the press are increasingly helpful.

The External Relations Group of the School, though small in number, has produced modest but significant results and looks forward with enthusiasm to providing serious, substantive support to the School.

* Compared to $285,000 for fiscal year 1979-80.
STAFF CHANGES, PROMOTIONS, AND VISITORS

During the past year, three faculty members were promoted to the rank of full professor. They are Professors Bailyn and Van Maanen of the Organizational Studies Group, and Professor Nyhart, who holds a joint appointment in the School of Management and the Department of Ocean Engineering.

Professors Berndt, McKersie, and Kochan joined the Sloan School as full professors. Professor Berndt, whose fields are applied microeconomics and applied econometrics, was formerly an associate professor at the University of British Columbia. Professor McKersie, a visiting professor at Sloan last year, accepted our offer to remain in the manpower and labor relations area. Professor Kochan, whose field is also industrial relations, came to us from Cornell University by way of the US Department of Labor.

Professor von Hippel was granted tenure at the rank of associate professor. Professor Bitran was promoted to the rank of associate professor.

Professors Hauser and Krugman were appointed to the faculty as associate professors. Professor Hauser, a holder of four degrees from MIT, came from Northwestern University to join the marketing area in the Management Science Group. Professor Krugman, who was a visiting assistant professor last year, was jointly appointed by the Sloan School and the Economics Department and is the holder of the Ford International Development Chair.

Three women and seven men were appointed to the rank of assistant professor. Professor Abraham, whose Ph.D. is expected from Harvard University, joined the Manpower and Labor Relations Group; Professor Jawaid A. Ghani, who will receive his Ph.D. from the University of Pennsylvania, joined the management information systems section of the Management Science Group; Professor Mel Horwitz, formerly assistant professor at the Harvard Graduate School of Business Administration, joined the corporate policy and strategy area; Professor Dorothy Leonard-Barton, who received a Ph.D. from Stanford University, joined the innovation, technology and health area. Professor M. Lynne Markus, a postdoctoral fellow in management information systems last year, joined that group as assistant professor. Professor Terry A. Marsh, a Ph.D. recipient from the University of Chicago, joined the Finance Group along with Professor Richard S. Ruback, who received his Ph.D. from the University of Rochester. Professor Ram T. S. Ramakrishnan, who received his Ph.D. from Northwestern University, and Professor H. David Sherman, a D.B.A. recipient from the Harvard Graduate School of Business Administration, joined the accounting and control area. Professor Julio Rotemberg, who received a Ph.D. from Princeton University, joined the economics area.

New members of the sponsored research staff are Elizabeth A. Flanagan and Supriya Lahiri, both of whom joined the Center for Computational Research in Economics and Management. Dr. Robert M. Alloway, formerly assistant professor at Sloan, joined the Center for Information Systems Research as a research associate.

We are happy to report that two Sloan School employees were promoted to administrative staff. Harriet L. Barnett was promoted to Coordinator for the Master's Programs and Rosemary Brutico was promoted to Assistant Managing Editor, Sloan Management Review.

We were pleased to have a number of visitors and guests at the Sloan School this year. Visiting scholars in the Finance and Economics Group were: Giovanni Andreatta, Bruna Ingrao, James B. McDonal, Kazuhiko Nishina, Jeongsik Park, and Joaquin Romero-Maura. Visiting the Management Science Group were Reinhard Angelmar, Ushio Sumita, and Mark S. Zachmann. Qing Rui Xu, Paul Roy, and Edward J. Bondik were guests of the Innovation, Technology and Health Group. Piotr Ploszajski and Shoshanna Zuboff were affiliated with the Organizational Studies Group. Visiting scholars in the Center for Computational Research in Economics and Management were L. Fraser Jackson and Pierre Y. Malgrange and, finally, Joseph Battat was a visitor in the international area.

Two faculty members were on sabbatical leave this year. Professor Kuh, on leave from the Economics and Finance Group, was involved in writing two books. Professor Magnanti, on leave from the Management Science Group, visited Harvard Business School and also completed some writing.
Seven faculty members were on leave of absence for all or part of the year. On leave for the academic year were Professors Alexander, William F. Pounds, Scott Morton, and Assistant Professors Toong and Martin Zimmerman. On leave for the spring term were Associate Professor Donald R. Lessard and Professor Edgar H. Schein.

We record with regret several departures from the Sloan School. Departing faculty include Professors Baldwin from Finance and Economics, Stephen J. Kobrin from the International area, and Lilien from the Management Science Group. Departing staff members are Ms. Chapman, Manager of External Relations, and Sarah S. Fitzgerald, sponsored research staff member in the Center for Information Systems Research.

ABRAHAM J. SIEGEL
Since I will soon lay down my responsibilities as Dean of Science to be a faculty member in the Department of Chemistry, I want to take this opportunity for a more historical perspective of the 14 years I have been privileged to have the challenges and personal relationships of being Dean. I have been the fourth Dean of the School. When the School of Science was established by President Karl T. Compton in 1932, Samuel Prescott was appointed Dean, and in 1942 his successor was George Russell Harrison. In 1964, Jerome B. Wiesner returned from Washington to be Dean of Science. Dr. Wiesner became Provost in 1966, and I became his successor as Dean of Science in February 1967.

During these 14 plus years, 24 individuals have served as Department Heads in the School of Science. I appreciate their dedication in working for the welfare of their departments and the Institute.

The changes in the School of Science over this period have been evolutionary rather than revolutionary, but there has been a significant improvement of the quality of the faculty. We are proud of the four Nobel Prize winners in the School of Science (Gobind Khorana, 1968; Salvador Luria, 1969; David Baltimore, 1975, and Samuel C. C. Ting, 1976) and the award of the Fields Medal, which is sometimes referred to as the "Nobel Prize in Mathematics," to Daniel G. Quillen. Other outstanding members of the faculty have been recognized by awards and prizes in their fields. Fifty-two of the faculty of the School of Science are members of the National Academy of Sciences.

It is interesting to look at enrollment trends over a period of 14 years, but even this is too short a period to accurately characterize the secular trends in the interests of undergraduates which determine the way they distribute themselves among the various Courses. When I became Dean of Science in 1967, there were 992 undergraduates in the School. This number increased to 1,197 in 1972-73, and then decreased gradually to 749 this past academic year. In contrast with this change for the School as a whole, the number of undergraduates in Course VII increased 60 percent over this period.

Graduate enrollments in the School of Science have been driven by a different set of factors over this 14-year period. In 1967 the graduate enrollment was 1,084. This declined to a low of 899 in 1971-72 and has steadily increased since to a current graduate enrollment of 1,114. The graduate enrollment in the biological sciences (Department of Biology and Department of Nutrition and Food Science) increased 32 percent over this period.

During my tenure as Dean, the undergraduates have been given greater flexibility in satisfying their General Institute Requirements. Fourteen years ago the General Institute Requirements included Chemical Principles (5.01), Calculus (18.01 and 18.02), and Physics (8.01 and 8.02). Since then freshmen have been offered various options which provide for a wider range of backgrounds and interests. The Chemistry Requirement has become a Chemistry-Biology Requirement which may be satisfied by 3.091, 3.40, 5.41, 5.60 or 7.01; the Calculus Requirement may be satisfied by 18.01, 18.001, 18.011 or 18.012 and 18.02, 18.002, 18.021, or 18.022, and the Physics Requirement may be satisfied by 8.01, 8.012, or 8.013 and 8.02, 8.021, 8.022 or 8.023. In addition the Experimental Study Group and Concourse provide alternate methods for limited numbers of freshmen to satisfy their science (Core) requirements.

The School of Science owes much to donors whose gifts have contributed to the quality of the School. It is impossible here to give a complete list of gifts in the past 14 years, but I want to especially acknowledge the gifts of four professorships by Cecil and Ida Green and the gift of an Astrophysical Observatory and Geophysical Observatory by George R. Wallace, Jr.
ACADEMIC PROGRAMS

The number of undergraduate majors in the School of Science this year was 749, compared with 797 the previous year. Thus the shift of the undergraduates to majors in engineering has continued. However, this shift has not caused a decline this year in the number of credit hours taught by the School of Science. The number of credit hours taught by the School was 242,811 this past year, compared with 233,679 for the academic year 1979-80, which is the same percentage (29.5 percent) of credit hours taught at the Institute as a whole.

In order to provide the freshmen with additional opportunities to learn about interesting research in the School and to hear about career opportunities in science, the School sponsored two programs this year. The first program, held on November 8, was called "Science Spectacular" and consisted of nine short talks on interesting science research programs at MIT. About 150 freshmen attended. The second program, on March 7, was called "Careers in Science" and consisted of seven talks by faculty members from the School of Science, and had about the same attendance. The departmental open houses for freshmen continued.

The enrollment of graduate students in the School of Science increased this past year both absolutely and relatively. The number of regular graduate students was 1,114, compared with 1,061 the previous year. The percentage of the Institute's regular graduate students that were in the School of Science was 26.0 percent this past year, compared with 25.6 percent the previous year.

The evolution of the science requirement subjects for freshmen continued this past year. The MIT faculty approved a new two-term sequence in calculus to be referred to as 18.011 and 18.021. These new subjects replace 18.01C and 18.02C and are specifically designed for students with high school calculus who are not ready to begin with 18.02. The new subject is broader and deeper than 18.01-18.02 and includes special topics and applications, such as probability or planetary motion.

These and other changes in the Core subjects and numerous operational matters were discussed by the Core Group, chaired by the Dean of Science. This group consists of the approximately 20 faculty members teaching the freshman science requirement subjects each term and a number of others interested in the instructional programs for freshmen. This includes officers from the Undergraduate Academic Support Office, Dean for Student Affairs Office, Office of Minority Education, and the Admission's Office. Professor Sheila E. Widnall, Chairman of the Faculty, and Dean Harold J. Hanham have been active members of this group. In addition there are regular student members. The group met six times during the year. Since the Committee on Educational Policy has been considering changes in Core requirements, the Core Group has frequently been used as a sounding board.

The Course XXV Master of Science program was terminated. One of the serious problems with this program has been the difficulty of arranging adequate financial support for students. We hope that graduate students who have interdisciplinary interests can be supported in departments that can provide them with the needed flexibility in planning their programs. The Course XXV Bachelor of Science program, of course, will continue.

RESEARCH

The research volume of the School of Science in fiscal year 1981 was estimated to be $37,100,000, compared with $31,725,000 for fiscal year 1980. This is a 17 percent increase. These totals do not include any portion of the volume of the interdepartmental laboratories which involve faculty members from the School. Estimates of the total research volume of the School of Science, including fractions of the interdepartmental laboratories that correspond with the participation of faculty members from the School, yield annual expenditures about double the above figures.

On March 6, the Spectroscopy Laboratory was dedicated as the George Russell Harrison Spectroscopy Laboratory in a ceremony involving Corporation Chairman Howard W. Johnson, President Paul E. Gray, Mrs. George R. Harrison, and the director of the Spectroscopy Laboratory.
School of Science

Michael S. Feld. Dr. Harrison co-founded the Spectroscopy Laboratory with President Compton in 1930 when Dr. Harrison came to MIT as Professor of Physics. In 1942 he became the second Dean of Science at MIT and served in that capacity until 1964. On the morning of March 6, there was a scientific symposium chaired by Provost Francis Low, at which Gerhard Herzberg, Edwin Land, and Charles Townes spoke. The Center has recently received additional space and has been remodeled to improve facilities for laser research.

The Institute's Council on Environmental Health and Safety met every two months during the year. It reviewed the activities of the presidentially appointed safety committees and received reports on safety activities in the departmental and interdepartmental laboratories. I made a report to the MIT faculty on March 18 on the activities of the Council, and reminded supervisors of their moral and legal responsibilities for safety. John M. Fresina, director of the Safety Office, and I served on committees writing the National Academy of Science report Prudent Practices for Handling Hazardous Chemicals in the Laboratory. On November 24, I chaired a public forum of the National Academy of Sciences on the disposal of low level radioactive biomedical waste.

This past year MIT signed an agreement with Dartmouth and the University of Michigan to construct a 2.4-meter telescope at Kitt Peak. We are already involved with these same universities in operating the McGraw-Hill Observatory at Kitt Peak. Fund-raising efforts are under way.

MIT joined Associated Universities for Research in Astronomy, Inc., which operates Kitt Peak National Observatory and other national facilities funded by the National Science Foundation.

FACULTY

One of the more striking changes in the faculty of the School of Science since 1967 is the increase in the number of women faculty members. In 1967 there was one woman faculty member in the School, and she did not have tenure. Now there are 19 women faculty members, nine of whom are tenured. There are women faculty members in all seven departments of the School. In 1967 there were no black faculty members; now there are three, one tenured and two nontenured.

Professor William F. Brace, Cecil and Ida Green Professor of Earth Sciences, was appointed Head of the Department of Earth and Planetary Sciences to succeed Professor Carl Wunsch, Cecil and Ida Green Professor of Physical Oceanography. The Department has prospered during Professor Wunsch's four plus years as Head.

Professor Peter Stone was appointed Head of the Department of Meteorology and Physical Oceanography to succeed Professor Edward Lorenz. During Professor Lorenz's four-year tenure as Head, the name of the Department was changed to symbolize its increased commitment to physical oceanography.

Professor Frank Press returned to MIT in January after serving as President Jimmy Carter's Science Advisor since 1977. Dr. Press was appointed as an Institute Professor. In January the National Academy of Science announced that Professor Press had been elected President of the NAS for a six-year term beginning July 1, 1981. We are sorry to have Professor Press leave MIT, but wish him well with his new responsibilities.

Several faculty members in the School were awarded named professorships this year. Professor Bernard F. Burke was appointed William A. M. Burden Professor of Astrophysics. Professor Christopher T. Walsh was appointed Uncas and Helen Whitaker Professor in the Whitaker College of Health Sciences, Technology, and Management. He serves as associate director of Whitaker College and as professor in the MIT Departments of Biology and Chemistry.

Career development professorships were awarded to several junior faculty members. Assistant Professor Alexander M. Kilbanov (Nutrition and Food Science) was the recipient of the 1981 Henry L. Doherty Professorship administered by the MIT Sea Grant College Program. Assistant Professor Michael A. Marletta (Nutrition and Food Science) was appointed as the first Mitsui Career Development Professor of Contemporary Technology. Assistant Professor William R. Roux (Chemistry) was appointed the Roger and Georges Firmenich Career Development Assistant Professor of Natural Products Chemistry. Gifts from the Kerr-McGee Foundation, Inc. and the Kerr Foundation have established

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the Kerr-McGee Career Development Professorship which will be held by a junior faculty member in the Department of Earth and Planetary Sciences.

Dr. Chia-Chiao Lin, Institute Professor and Professor of Applied Mathematics, was selected as the 1981-82 recipient of the James R. Killian, Jr., Faculty Achievement Award.

Vice President for Research Thomas F. Jones appointed two faculty members from the School of Science as directors of interdepartmental laboratories. Professor Jerome I. Friedman (Physics) was appointed director of the Laboratory of Nuclear Science to succeed Professor Low when he became Provost, and Professor Peter A. Wolff (Physics) was appointed director of the Francis Bitter National Magnet Laboratory to succeed Professor Benjamin Lax (Physics) who had served as director since the establishment of the Laboratory in 1960. Professor Wolff had served as Director of the Research Laboratory of Electronics since 1976.

Professor George B. Benedek (Physics) and David Botstein (Biology) were elected members of the National Academy of Sciences. Professor Maurice S. Fox was elected as a member of the Institutes of Medicine.

Professor Robert D. Rosenberg came to MIT as Professor of Biology and Professor in the Whitaker College of Health Sciences, Technology, and Management.

Professor David Hume (Chemistry) retired and is teaching at Wellesley College.

Professor Jule Charney, Alfred P. Sloan Professor of Meteorology, died on June 16, 1981, after a long illness. The American Geophysical Union awarded Dr. Charney the William Bowie Medal in 1976 and credited him with having "guided the postwar evolution of modern meteorology more than any other living figure." Professor Charney's research dealt with such problems as large-scale atmospheric turbulence, feedback interactions between the oceans and atmosphere, the persistence of certain abnormal flow patterns in the atmosphere, and the relationship of such phenomena to droughts. He was a major contributor to the development of meteorology and physical oceanography at MIT, and served as Head of the Department from 1973 to 1977.

ROBERT A. ALBERTY

Department of Biology

In the past year, 234 undergraduates were listed as majors in Life Sciences and 96 received the degree of Bachelor of Science in Life Sciences. Most of these graduates will be attending medical school or graduate school. In the past year, 12 Ph.D.s were awarded in the Department and one in the Joint Program in Biological Oceanography with the Woods Hole Oceanographic Institution. There were 130 Ph.D. candidates registered in the Department and another 23 in the Joint Program. There were 38 students in the entering graduate class in 1980, and there will be 23 in the entering class in September 1981. We have deliberately decreased the number of entering graduate students for the 1981-82 academic year because of our concern for dwindling support of graduate programs by the granting agencies of the government.

EDUCATIONAL ACTIVITIES

The Departmental subjects required of all students who become majors in Life Sciences are 7.05 General Biochemistry, 7.03 Genetics, and 7.011 Introduction to Experimental Biology. Although it is not listed as a strict requirement, 7.01 General Biology is also taken by most students. These are the basic subjects listed as prerequisites for the other subjects which appear on the restricted elective lists in the undergraduate curriculum. Since we are anxious that all interested students should have the opportunity to acquire experience in laboratory research, we have made available a series of research-oriented project laboratories in the areas of biochemistry,
cell biology, immunology, microbiology, and genetics. These laboratory subjects are staffed by faculty and other research personnel. Each student enrolled in such a subject chooses a research project and, with the help of the staff, is expected to make significant progress during the semester. These project laboratories have been exceptionally well received by the students. The experience is particularly valuable for students who wish to continue to do work in the research laboratories of individual faculty members.

In the fall semester of 1980-81, the Department offered for the first time a new undergraduate subject on Current Concepts in Biology (7.00). This new subject includes a discussion of topics such as genetic engineering, recombinant DNA technology, antibody synthesis, and organization of cell membranes. It has been designed for students who are probably not going to be majors in Life Sciences, but who would like to acquire information about the current state of biological research. The subject was organized and is being taught by Professors David Baltimore and Harvey Lodish.

The recipients of the annual John L. Asinari Awards for the 1980-81 year for outstanding research by undergraduates in Life Sciences were Anne Bagg (Class of 1981) and Gerald Fitzgerald (Class of 1982).

One new graduate subject was added to the curriculum in the 1980-81 academic year. Professors Robert Sauer, Uttam RajBhandary and Jonathan King organized and taught a subject on Structure, Function, and Assembly of Biological Macromolecules. This new subject is expected to become an important part of the training of those graduate students who are concentrating in the area of biochemistry.

RESEARCH

The research activities of the Department are in the broad area of molecular biology with emphasis on the following specific disciplines: biochemistry, genetics, microbiology, cell and developmental biology, biophysics, virology, immunology, and neurobiology. Individual research projects are described in the annual Departmental publication, *Biology Research Summaries*, available at the Department’s headquarters.

PERSONNEL

Three new faculty appointments were made during the year. Dr. Leonard P. Guarente was appointed an assistant professor. Dr. Guarente received the S.B. in Life Sciences from MIT in 1974 and the Ph.D. from Harvard in 1978. Since then, he has been a postdoctoral trainee at Harvard. He will join the Department in October 1981. Dr. Guarente’s research work is in the area of the regulation of gene expression.

In February 1980, Dr. Monty Krieger joined the faculty as an assistant professor. Dr. Krieger received the B.S. in Chemistry from Tulane University in 1971 and the Ph.D. from the California Institute of Technology in 1976. After spending one year as a research fellow at Cal Tech, he then became a postdoctoral fellow at the University of Texas Health Science Center at Dallas and remained there until he came to MIT. Dr. Krieger holds a joint appointment in the Department of Biology and the Whitaker College of Health Sciences, Technology, and Management. His research laboratory will be in the new Whitaker College building. Dr. Krieger’s research interest is in the area of receptor biology with specific emphasis on receptor-mediated endocytosis.

A second joint appointment with the Whitaker College has also been made. Dr. Robert Rosenberg will join the faculty as a professor in the fall semester of 1981-82. After receiving the M.D. from George Washington University in 1961, Dr. Rosenberg spent two years as a medical resident and then entered graduate school in the Department of Biology at MIT. He received the Ph.D. in Biophysics in 1969, and for the past 12 years he has been a faculty member at Harvard Medical School. Dr. Rosenberg is recognized as a leader in the field of thrombosis.
During the year Dr. David Housman was awarded tenure and Dr. H. Robert Horvitz was promoted to associate professor.

Dr. Howard Green has left the Department to become the chairman of the Physiology Department at Harvard Medical School, and Dr. Raymond Baker has also recently departed to become a faculty member at State University of New York at Buffalo.

Professor King spent a portion of the year on sabbatical leave.

Dr. Samuel A. Latt, from the Harvard Medical School, spent the year in the Department in Professor Baltimore's laboratory. Dr. John R. Geiger, on leave from Smith College, spent the year working in Professor Graham Walker's laboratory, and Dr. Alan Schwartz, from Harvard Medical School, was a part-time visitor in Professor Lodish's laboratory.

We are pleased to report the following honors and awards: Dr. Alexander Rich, Sedgwick Professor of Biology, was selected as the recipient of the 1980-81 James R. Killian, Jr., Faculty Achievement Award; Dr. Maurice S. Fox, Lester Wolfe Professor of Molecular Biology, was honored by his election to the membership of the Institute of Medicine; Professor David Botstein was elected to the National Academy of Sciences; and Dr. Christopher T. Walsh, professor of Biology and Chemistry and associate director of the Whitaker College of Health Sciences, Technology, and Management, was appointed as the Uncas and Helen Whitaker Professor in the Whitaker College.

GENE M. BROWN

Department of Chemistry

GENERAL

The Bachelor of Science in chemistry was awarded to 47 undergraduates this year: three in February, and 44 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 one candidate in February. A total of 36 Ph.D.s were awarded to eight candidates in September, 14 in February, and 14 in June. To date, 1,631 Ph.D.s and 385 Master's degrees have been awarded by the Department.

We were saddened by the death in February of Professor, Emeritus, James A. Beattie, who had been associated with MIT for over 65 years as a student and faculty member. A year ago Professor Beattie had published a new book, Principles of Thermodynamics, with Professor Irwin Oppenheim.

FACULTY

At the 1981 national meeting of the American Chemical Society, Professor Mark S. Wrighton was presented the ACS Award in Pure Chemistry, sponsored by Alpha Chi Sigma Fraternity. Professor Dietmar Seyferth received the ACS Award for Distinguished Service in the Advancement of Inorganic Chemistry at the same meeting. Professor Mary Roberts received a Dreyfus Foundation Teacher-Scholar Award, and Professor Rick Danheiser was named Alfred P. Sloan Research Fellow.

Professor Edward I. Solomon was promoted to professor and Professor William H. Rastetter to associate professor. Professor William Roueh was named as the second holder of the Roger and Georges Firmenich Career Development Assistant Professorship in Natural Products Chemistry. Professor Christopher Walsh, professor of Chemistry and Biology and associate director of the Whitaker College was named to the Uncas and Helen Whitaker Chair in Whitaker College.
Department of Chemistry

Professor K. Barry Sharpless rejoined the departmental faculty from Stanford University. Two new assistant professors, Dr. Sylvia T. Ceyer and Dr. Keith A. Nelson joined the faculty for the coming year. Professor David N. Hume retired, and Professor Ralph H. Staley resigned from the faculty. Professors Robert Field and Jeffrey I. Steinfield were on sabbatical the second term.

The Department was privileged to sponsor lecture series provided by the Arthur D. Little, T. Y. Shen, and Karl Pfister professorships. Dr. Hubert Schmidbaur of the Technische Universität München delivered A. D. Little Lectures in inorganic chemistry on the topics "Gold-Ligand and Gold-Gold Interactions in Some New Coordination Compounds," "New Phosphaneborane Chemistry," and "The Unexpected Role of Phosphorus Ylides in Inorganic and Organometallic Chemistry."

A. D. Little Lectures in physical chemistry were presented by Dr. John T. Yates, Jr., of the National Bureau of Standards, Surface Science Division, who spoke on "Structure of Chemisorbed Species on Single Crystal Metal Surfaces," "Surface Vibrational Spectroscopy -- A Sensitive Probe of Bonding and Interactional Phenomena in the Chemisorbed Layer," and "Dynamics of Chemical Reactions on Single Crystal Metal Surfaces." Professor Koji Nakanishi of Columbia University was the T. Y. Shen Visiting Professor. His topic was "Isolation and Structural Studies of Bioactive Compounds," "Studies in Visual Pigments and Bacteriorhodopisin," and "Exciton Chirality Method Applied to Oligosaccharide Structure Determination." The Karl Pfister Lecturer was Professor R. U. Lemieux of the University of Alberta, who lectured on "Methodologies for the Chemical Synthesis of Complex Oligosaccharides," "The Synthesis and Conformational Properties of Oligosaccharides Corresponding to Human Blood Group Determinants," and "The Exploration of Human Tissues, Plasmas and Secretions by Way of Chemical Synthesis," Northeast Coast Lecturer, Professor Duilio Arigoni of the Eidgenössische Technische Hochschule, Zürich, presented a lecture on "Mechanistic Studies Involving Chiral Methyl Groups." Professor Melvin Calvin of University of California, Berkeley, was the speaker for the Nobel Laureate Lecture Series, sponsored by J. T. Baker Chemical Company and the Chemistry Department. His topic was "Petroleum Plantations." Graduate students in the Department, with the help of alumnus Dr. Charles Kolb, organized and held two career development seminars. At each, a panel of four departmental alumni discussed their careers in industry and responded to questions and discussion.

The Department's Chemical Sciences/Industry Forum will complete its fifth year of operation in 1981. The Forum has proved an effective vehicle for strengthening their ties between the Department and related industries. Among the activities of the Forum are periodic topical symposia. "Synthetic Processes and Methods" was the topic of a Forum symposium this year.

RESEARCH

Vigorous research activities in the main areas of chemistry continue to be a major focus in the Department. Some examples are summarized in the following paragraphs.

Theoretical Chemistry

Research activities in Professor John Deutch's group span a wide variety of subjects in theoretical physical chemistry. Major attention is placed on 1) concentration effects on the rate of diffusion-controlled reactions, 2) development of models for combustion in fuel sprays, 3) light scattering from multi-subunit molecular assemblies and polymer gels, and 4) polymer conformation near the theta point. With support from the MIT Center for Energy Policy Research, Professor Deutch undertakes some work on energy technology issues, particularly technical aspects of radioactive waste management.

An especially noteworthy result recently discovered by Professor Deutch concerns the conformation of polymer chains at the "theta point." In two-dimensional systems, as the theta point is approached, the polymer chain is "swollen" from the ideal Gaussian chain behavior due to the interaction that arises from the repulsion between separate segments. The theta point of the solution is the temperature where the polymer conformations revert to ideal behavior. Microscopically, at this point, the effective pair interaction between monomer units vanishes; segments no longer are attracted to solvent molecules in preference to themselves.
School of Science

What is the implication of this microscopic picture for conformations in two dimensions? The astonishing fact is that vanishing of the pair interaction does not lead to ideal behavior. This fact was originally discovered by de Gennes by analogy to thermodynamic tricritical points. Using an approximate field theory computational method, he calculated that at the theta point in two dimensions $R_\infty \approx N^{0.53}$. However, a different approach using a generalization of more conventional mean field arguments predicted $R_\infty \approx N^{0.56}$. Experiments by Vilanove and Rondelez on polymers floating on water suggest $R_\infty \approx N^{0.56}$. In order to resolve these discrepancies, Professor Deutch has developed a method based on the real space renormalization group. The method is of general applicability to polymer problems of interest and is much simpler than the field theoretic approach. Initial results suggest an exponent in the range $0.53 - 0.68$ which is in better agreement with experiments than the de Gennes result and indeed may well prove to agree very closely with the mean field value of $(2/3)$.

The significance of this work is that it sharpens our understanding of the macroscopic manifestation in polymer configurations of the microscopic circumstances that determine the theta point. In addition, a new method has been extended to deal with a variety of polymer problems than heretofore possible.

Synthetic Organic Chemistry

Professor Satoru Masamune's research program leans heavily towards acyclic stereoselection, one of the most fundamental and general problems in synthetic organic chemistry. Numerous natural products of chemical and physiological significance are basically acyclic, uniquely and regularly oxygenated, and rich in chirality. The synthesis of these compounds had remained unexplored until recently, because of the lack of general principles and synthetic methodology to bring about several vital transformations with high stereoselection and in mild reaction conditions.

The specific aims of this project are to establish a general approach to the total synthesis of several representative macrocyclic antibiotics and to explore newer methods of constructing the $\beta$-hydroxycarbonyl and $\beta$-hydroxy-$\alpha$-methylcarbonyl systems, basic structural units present in the antibiotics. The selected target molecules are a) the polyoxomacrolides, methymycin, narbomycin, $\beta$-deoxyerythronolide B, and tylosin, b) the ansamycins, rifamycin S and streptovaricin A, and c) the polyenemacrolide amphotericin B. Several of them have already yielded to synthesis. An understanding of complicated interactions among many chiral centers involved in a reaction system has led to a unique device of several chiral boron reagents which are capable of effecting the aldol condensation with near-perfect stereocontrol. With this and other developments it is now possible to construct, with a preselected absolute configuration, numerous basic fragments required for the total synthesis. Thus, Professor Masamune's recent work is highlighted with the successful synthesis of $\beta$-deoxyerythronolide B which has been executed with remarkable diastereo- and enantioselection through the almost exclusive use of the newly developed reagents. Together with the macro-cyclization technique developed by Professor Masamune in methymycin synthesis and applied to the complex acyclic seco-acids derived from several other antibiotics, the aldol-based seco-acid route has been firmly established as a general and efficient approach to the synthesis of many natural products of the polycarbonate and polypropionate type. A majority of complicated problems associated with the synthesis of palytoxin, $C_{123}H_{223}N_3O_{14}$, perhaps the most complicated and largest organic molecule ever known to organic chemists with approximately 60 chiral centers (10$^{18}$ possible stereoisomers) and a non-repeating $C_{123}$-straight chain, have already been solved, at least in principle, and work toward its synthesis is now under way.

Enzymes achieve the biosynthesis of a natural product with remarkable efficiency and stereoselection and through a complicated mechanism. A final goal of the research in Professor Masamune's group is the mechanistic elucidation of the carbon-carbon bond forming reactions, such as acyl transfer and aldol reactions. These reactions are involved in an initial stage of the biosynthesis of fatty acids, and more generally the lipid-derived metabolites including most of the presently known natural products. Several bacteria in the genus Zoogloea ramigera produce a $\beta$-ketothiolase which has been isolated in the laboratories of Professor K. Tomita, Kyoto University. A long-range project involving the purification, crystallization, and structural elucidation of the enzyme and mechanistic studies of the enzymatic reaction has now been launched with the collaboration of Professor Gregory A. Petsko and Dr. Dagmar Pondz of the Department.
Biophysical Chemistry

Professor Petsko is working on understanding the relationship of structure to function in macromolecules. Broadly, this research has three areas of concentration:

1) The origin of the catalytic power of enzymes. Enzymes are proteins which catalyze chemical reactions. Their catalytic efficiency is enormous: for example, many enzymes speed up their reactions by more than $10^{10}$. It is believed that the origin of this great efficiency must lie in the detailed atomic structure of the enzyme and its atomic interactions with substrate. In Professor Petsko's laboratory, the technique of X-ray crystallography is used to determine the exact location in space of the more than 2,000 atoms that make up a typical protein. Sub-zero temperatures slow down an enzymatic reaction that normally takes one second until it takes six weeks; under these conditions, the complex of the enzyme with its substrate can be examined in atomic detail. This has been done for two enzymes: ribonuclease A, which hydrolyses RNA, and triose phosphate isomerase, which uses 2,500 protein atoms to shift a single proton. Professor Petsko and his co-workers have also sequenced the gene for the isomerase and are now trying to make specific mutants with altered function. For both of these enzymes they have deduced mechanisms for the catalytic event.

The current X-ray structural work concentrates on an enzyme which detoxifies the superoxide ion and a single enzyme which catalyzes two different reactions.

Some of these projects on enzymes are being done in collaboration with Professors William Orme-Johnson and Roberts, and Dr. Ponzi.

2) Biochemical signaling. This work focuses on how information is passed from one cell to another or from one organ to another. Often this is done by means of interactions between two different proteins. Bacteria possess a rudimentary sense of "smell" which may be a model for the sensory systems of higher organisms. Nine different proteins control this sense. Professor Petsko is trying to isolate, purify, and study all nine. The first two have already been purified in his laboratory.

A medically important signaling system found in humans is the allergic response. The pathway from inhaling ragweed pollen to the sneeze is a complex one. Professor Petsko's group has begun the study of this by obtaining the principle allergic factor from ragweed pollen. It is a small protein, which functions by interacting with a protein antibody in the immune system. Thus, allergy is just an overdeveloped reaction against a foreign invader. Characterization of this reaction is the goal of current work. Professor Richard Lord is a collaborator on these projects.

3) Protein dynamics. Proteins are not rigid. In solution they fluctuate rapidly; these fluctuations are believed to be important for their biological function. A method has been developed in Professor Petsko's laboratory for measuring the average displacement of every atom in a protein. This method allows the determination of which regions in a protein are flexible, and how the flexibility changes as the molecule carries out its function. This has been applied to the oxygen storage protein myoglobin and to its complexes with oxygen and carbon monoxide.

JAMES LLOYD KINSEY

Department of Earth and Planetary Sciences

FACULTY

The Head of the Department, Carl Wunsch, Cecil and Ida Green Professor of Physical Oceanography, resigned effective July 1, 1981, and will be succeeded then by William F. Brace, Cecil and Ida Green Professor of Geology. Institute Professor Frank Press was with the Department during the spring term after relinquishing his post as Science Advisor to President Jimmy Carter. Dr. Press begins his new position as President of the National Academy of Sciences on July 1, 1981.
Professor Gordon Pettengill has been on leave in Australia during the past year. Associate Professor John Edmond was promoted to full professor effective July 1, 1981, and has been on sabbatical at the University of Paris during the spring term. Dr. Barry Parsons, principal research scientist in the Department, has been appointed Associate Professor of Geophysics. Professor John Hunt of Woods Hole Oceanographic Institution was Crosby Visiting Professor during the spring term.

Honors

Kei Aki has been appointed Distinguished Visiting Professor at the University of Alaska, a position made vacant by the death of Sir Edward Bullard. Professor M. Nafi Toksoz was elected a Fellow of the American Association for the Advancement of Science, and Professor Timothy L. Grove received a similar honor from the Mineralogical Society of America. A Guggenheim Fellowship and a Fulbright-Hays Award were received by Professor Wunsch.

RESEARCH

The Department conducts an active program in research in most areas of earth and planetary sciences. There is a distinct observational orientation to much of the research, and our operations are global in scope with faculty, students, and staff working in the field both on land and at sea. The research operations of the Department are far too large to be described in any detail here. Much more information can be found in the annual research book published by the Department and which is available on request. Here, only a few suggestive examples of some of the highlights of research in the Department will be given.

Note that the division into different categories, e.g., Geochemistry, Geology, Planetary Science, is in many cases completely arbitrary given the multidisciplinary nature of much of the work.

Geology

Professor Clark Burchfiel and his colleagues have continued their work in Hungary. They have produced what may be the first comprehensive tectonic synthesis of the relationship between the development of the intra-Carpathian basins and the evolution of the corresponding orogenic belt. The history of the basins indicates they were formed by crustal extension followed by a slower thermal subsidence. The extension can be correlated with migration in the terminal phases of thrusting and volcanic activity eastward in the Carpathian arc. Opening of the basins seems to have been driven from the east by retrograde motion of the subductive slab. Using the large experimental flumes available at MIT, Professor John Southard has continued his research on the mechanics of sand transport by water and air. The goal is to interpret current-generated structures found in ancient sedimentary rocks. From a series of experimental runs they have found that sedimentary structures generated by migration of the bedforms in the experimental flume vary substantially as a function of flow velocity. This study and its continuation will enhance the ability to make paleo-flow interpretations in ancient rocks.

The rock mechanics group in the Department continues to be quite active. Professor Brace and his colleagues have shown that the role of clay is not unique in weakening faults. They have found that crushed granitic rocks, for example, became as impermeable as clay after they had undergone prolonged shearing. This result is important because it was believed that fault creep was promoted through fluid being trapped by the low permeability of clay. A similar role seems possible with quartz powder. Dr. J. B. Walsh has been doing a theoretical analysis of the changes effected by fluid pressure and external stress upon the properties of fractures such as joints and microcracks. His results show encouraging agreement with laboratory and field data.

Experimental work on microcracks has been continued by Professor Gene Simmons and his group. Among other results, they have showed that uranium and rare earth elements are present in sealed microcracks and therefore are mobile and move through them.

Professor William Pinson has continued his work on the large circular ring features of Ontario province and his fieldwork on the general geomorphological features of the Canadian sub-Arctic.
Geochemistry

The research group of Professor Roger Burns has been developing techniques for identifying minerals in soils on planetary surfaces and in deep-sea sediments. They have demonstrated that feroxyhyte and not maghemite occurs in the Martian soils and probably accounts for many of the apparently anomalous results obtained during the Viking Lander experiments (including the biological ones).

Professor Stanley Hart and principal research scientist Nobumichi Shimizu, using the MIT-Harvard-Brown ion microprobe facility, have shown that trace elements which are incorporated in growing phenocrysts are controlled by kinetics of interface processes such as the attachment of SiO₂ chains and the absorption and desorption of trace elements. The trace element modeling of volcanic rocks may require revision if the behavior of these elements in magmatic crystallization processes is indeed generally controlled by interface kinetics.

Professor Frank Spear has completed a systematic geothermometric and geobarometric study of pelitic schists in the vicinity of Mt. Moosilauke, New Hampshire. The study is one of the first aimed at analyzing the internal consistency of independently derived geothermometers and geobarometers. The results compare very favorably with experimentally determined values for the Al₂SiO₅ invariant point.

In another petrologic study, Professor Grove has completed a study of the lunar green glasses from the Apollo 15 landing site. He has been able to use major-element variations to determine the depth of origin and the crystalline phases in the source that was melted to produce the green glass magma. Eruption of the magma at the lunar surface must have produced a spectacular volcanic fire fountain. An immiscible sulfide-rich liquid has been identified as the volatile phase that powered the eruption event.

Studies of Hawaiian volcanism have enabled Professor Fred Frey to define the composition and mineralogy of the upper mantle beneath Hawaii and the degree of melting required to generate Hawaiian basalts. He finds there is strong evidence for recent migration of a fluid component within the mantle which establishes one mechanism for creating mantle heterogeneity.

Geophysics

Professor Toksoz and his group have been increasing their studies of seismic drill holes for petroleum exploration. They have been studying the seismic properties of oil- and gas-bearing formations by acoustic measurements in a drill hole and by vertical profiling techniques as well.

Professor Aki has succeeded in using geological observations to obtain an initial model of earth and earthquake structure for data inversion. He has determined the three-dimensional structure and the earthquake locations simultaneously in studies of a moderate California earthquake.

The application of geophysical techniques to the tectonics of the terrestrial planets has been an area of interest for Professor Sean Solomon. He and his colleagues have determined the thickness of the elastic lithosphere from the tectonic response to loads on the moon and on Mars. They have shown indications of strong lateral variation in lithospheric thickness on both planets. This variation appears to be primarily the result of impact heating early in planetary history and of mantle dynamics and volcanism later on.

Professor Peter Molnar and his group along with colleagues in the People's Republic of China have carried out what is probably the most careful study of foreshock sequences in earthquakes yet to be made. They found that the foreshocks did not occur on the same fault plane as the main shock but were displaced from it by six to eight km. This will necessitate the rethinking of the relationship of foreshocks and main shocks in earthquakes.

In studies of induced polarization, Professor Ted Madden and his students have resolved a long-standing mystery of the apparent insensitivity of sulphide mineral induced polarization response to a wide variety of chemical environments. The answer to the problem seems to be due to solute adsorption phenomena. They also have shown that copper bearing sulphide minerals have a distinctly different induced polarization signature than either pyrite or graphite, leading to a sound basis for geophysical exploration techniques known as spectral induced polarization.
Oceanography

Professor John Sclater and colleagues at the Scripps Institution of Oceanography have been working on the tectonic history of the Southwest Indian ridge. They have mapped a series of transform faults and fracture zones on this active ridge system and have established a simple and straightforward geological history for the relative motion of the Antarctic and African plates.

Principal research scientist, Dr. Parsons, together with colleagues, has made a global study of long-wavelength depth and geoid anomalies. The direct correlation of these two observables and the magnitude and wavelength of the anomalies can be interpreted in terms of convection beneath the tectonic plates with horizontal length scales much smaller than the plates themselves.

Professor Edward Boyle has established that recent fossil foraminifera on the seafloor contain a record of trace element chemistry of the water in which they live. With this relationship, he is now in a position to study changes in ocean chemistry over the last million years. He has shown that the Mediterranean dessication of six million years ago should have changed the Sr/Ca ratio of seawater by five to ten percent.

Using arrays of current meters and tide gauge data taken in the Pacific and Indian oceans, Professor Charles Eriksen has verified that low baroclinic modes of equatorial wave functions dominate the observed variability in currents and sea level. At periods of weeks, modes are Kelvin waves; at high frequencies they are equatorial gravity waves excited at discrete frequencies.

The large-scale circulation of the North Atlantic Ocean is being studied by Professor Wunsch and his students and colleagues by the use of so called linear programming methods. They have shown that these and related mathematical techniques appear to be the natural mathematical tool for the determination of the large scale time average movement of water mass tracers.

Planetary Science

Using the Cerro Tololo Interamerican Observatory, Professor James Elliot has established the orbits of the nine Uranian rings now known. From the precession of the rings they have obtained the $d_2$ and $J_4$ coefficients of the Uranian gravitational potential -- quantities fundamental for determining the interior structure of the planet.

Professor John Lewis and co-workers have been studying the disequilibrium processes of planetary atmospheres. Optical and radio-frequency evidence for lightning have been shown to imply that lightning is negligible as a source of organic and colored matter on Jupiter contrary to what had been previously believed.

Professor Irwin Shapiro's very-long baseline interferometry group and their collaborators have made unprecedentedly accurate measurements of the earth's polar motion and rate of rotation. The daily uncertainties have been reduced to under 10 cm and 0.2 msec, respectively.

The development of a system of miniature radio-interferometer terminals for accurate geodetic measurements has been proceeding under the direction of Professor Charles Counselman. Recent tests of this system have shown that sub-centimeter accuracy in three dimensions is attained in less than an hour of averaging-time for the determination of relative positions of points less than a kilometer apart. It is planned to use this system as a very low frequency seismometer in earthquake zones.

ENROLLMENT

Our graduate enrollment has remained constant with 80 students in Course XII and 24 in Course XII-W, the Joint Program in Oceanography with the Woods Hole Oceanographic Institution. The slight drop in numbers of Joint Program students was caused by the registration of all the Physical Oceanography graduate students entering in September 1980 in XIX-W, instead of XII-W. We had 35 undergraduates enrolled in the Department, the majority of whom are actively engaged in research projects with various faculty members.
We awarded the following degrees during the past year: 14 Bachelor of Science, nine Master of Science, eight Doctor of Philosophy (XII), and eight Doctor of Philosophy (XII-W).

CARL WUNSCH

Department of Mathematics

During the 1980-81 year there were 177 undergraduates and 120 graduates majoring in Mathematics. The Bachelor of Science was granted to 47 students during the year. There were seven recipients of the Master of Science and 21 recipients of Doctor of Philosophy in Mathematics.

UNDERGRADUATE AND GRADUATE PROGRAMS

The Student Mathematics Committee has been quite successful in bringing students closer to the center of Department activities. Activities for faculty and students have included a weekend at MIT's Talbot House in Vermont, talks and teas, and a dinner. The Committee published a splendid "Math Majors' Magazine," with math, games, news, and advice.

The Department has been grappling with a number of questions about the Institute Calculus Requirement, involving content, perspective, depth, and format. There are no plans to replace calculus by other mathematics. It is hard to imagine another single framework so central, so progressive, and so rich in applications.

However, there are some modest changes planned for the fall of 1981. The 18.01C-18.02C series, which covered all of calculus in a semester and a half, will be replaced by a deeper, broader, year-long version, 18.011-18.021. The new 18.011-18.021 will include special topics and applications such as probability or planetary motion. Also, 18.01A-18.02A will cover fewer topics, in a deeper, more demanding way. The other calculus sequences, 18.001-18.002 and 18.012-18.022, already provide in some ways deeper, more disciplined approaches to calculus and will remain unchanged.

The growing importance of computers makes their use in freshman mathematics appealing. To make their use also genuine, interesting, and substantial is difficult but essential. One promising program now under development will have students solve realistic problems by interacting with a video screen.

The Department has for a number of years used videotaping, classroom observation, and seminars to help faculty and TAs improve their teaching. As a result of efforts this spring, the insights gained will be spread this fall to a wider group at MIT. In collaboration with the Undergraduate Academic Support Office, an ad hoc committee chaired by Professor Arthur Mattuck has prepared a 60-page booklet of teaching suggestions, to be distributed as desired by the MIT departments to their TAs and junior faculty, and anyone else who wants one. Publication will be paid for by the Class of 1922 Fund associated with Professor Mattuck's chair.

A new fellowship, which we have named in memory of Norman Levinson, was given to the Department by the Institute, and we are very pleased to have it. The fellowship provides tuition and a stipend for one graduate student in pure mathematics each year. It comes at a time when outside support for graduate study in pure mathematics has become critically low; this cutback has hurt us more than mathematics departments at other leading schools as they each already have several such fellowships.
School of Science

FACULTY

The Department has appointed a number theorist, Andrew Wiles, as an associate professor with tenure, and an analyst, David Jerison, as an assistant professor. Both are on leave this year and we look forward to their arrival for the 1982-83 academic year.

Victor Kac and Michele Vergne were both promoted to full professor. David Vogan (group representations) and Gary Miller (computer science) were promoted to associate professor. Jeff Kahn (combinatorics) has been promoted to an assistant professor of applied mathematics. He will be on leave with an NSF grant his first year in this position.

Faculty members on leave during the past year were: Professor Gilbert Strang (spring), Professor Richard Stanley (spring), Professor George Whitehead (spring), Professor Harold Stark (spring), Professor Louis Howard (spring), and Leonard Adleman.

Shelley Rasmussen was appointed an assistant professor of applied mathematics (in statistics), and John Buoncristiani, also in statistics, was appointed as an instructor. For next year Lawrence Gillick (statistics) will be a visiting assistant professor of applied mathematics. Donna Neuberg has been a research associate in statistics this past year.

Professor Harvey P. Greenspan has been appointed as chairman of the Applied Mathematics Committee.

Honors

Professor C. C. Lin received the James R. Killian, Jr., Faculty Achievement Award.

Professor Herman Chernoff was inaugurated into the National Academy of Sciences and was offered the Townsend Harris Medal by election of alumni of CUNY.

Professor William DuMouchel was elected Fellow of the American Statistical Association.

Dr. Buoncristiani was awarded a Fulbright lectureship for the year 1981-82, but requested a postponement for one year due to his recent appointment here.

We had four postdoctoral associates this year; Marc Brachet, visiting from France, John Dickinson (theoretical physics), James Shearer, and Kenneth Berman (combinatorics).

The following people held visiting appointments: Professor Anil Nerode (Cornell University), Professor Julian Keilson (University of Rochester), Professor Herbert Solomon (Stanford University), Professor Charles Stone (UCLA), Professor Jean Leray (College de France), Professor Jean Spaltenstein (Universite de Lausanne), Assistant Professor Michael Akritas (Athens, Greece), Assistant Professor Saj-Nicole Joni (who will be teaching at Wellesely College next year), Professor Takahiro Kawai (Kyoto University), and Professor Neil Grabois (Williams College).

The Statistics Center has been formed and will do consulting and collaborative research with other departments. It has received support this year from the Office of Naval Research, the National Science Foundation, the Environmental Protection Agency (Effect of Radon on Lung Cancer), and the Department of Transportation (air traffic). Additional visitors in the area of statistics were Professors John Bather (England), Andrew Rukhin (Russia), and Ehsanes Saleh (Canada).

We are very pleased to note that Professors Vergne and Kac announced the arrival of their first child.

DANIEL J. KLEITMAN
Department of Meteorology and Physical Oceanography

The Department of Meteorology and Physical Oceanography was saddened by the death of our senior member and former Department Head, Professor Jule G. Charney, on June 16, 1981. Professor Charney was universally recognized as the leading theoretical meteorologist of the past few decades, and he, more than any other person, was responsible for the transformation of weather forecasting from a craft to a science. His passing will mean a great loss to the Institute and to the atmospheric and oceanic sciences.

Our Department, formerly the Department of Meteorology, acquired its new name this year, following recognition that we have long been involved in oceanography, and have been awarding the S.M. and Ph.D. in Oceanography for the past two decades. Concurrently with our name change, Professors Carl Wunsch and Charles Eriksen of the Department of Earth and Planetary Sciences, both physical oceanographers, were given joint appointments in the two departments.

We have further strengthened our oceanographic program by appointing Dr. Paola Rizzoli as an assistant professor of oceanography. Dr. Rizzoli comes from Italy, where she has participated in expeditions on the Adriatic Sea in addition to being deeply involved in theoretical work.

Through the generosity of some alumni and friends of the Department we have established a few awards, to be offered annually to outstanding applicants for admission as a supplement to their ordinary financial support. The awards, financed by the gift of one alumnus, will be called the Victor Starr Awards, in memory of the late Professor Starr of our Department who did so much to promote excellence in meteorological research.

Through the efforts of a committee headed by Professor Mark Cane, our Department has established a computation center. This facility contains a medium-sized computer and peripheral equipment, and remote terminals which will enable students and staff to contact MIT's Information Processing Center and several other large computers.

Professor Ronald Prinn received the James B. Macelwane Award of the American Geophysical Union, given annually for "significant contributions to geophysical science by a young scientist of outstanding ability." Professor Charney was elected an honorary member of the Royal Meteorological Society, while Professor Edward Lorenz was elected an honorary fellow of the Indian Academy of Sciences and a member of the Norwegian Academy of Science and Letters. We are especially pleased that George Huffman, one of our graduate students and our representative on the Graduate Student Council, was the sole graduate student this year to receive one of MIT's Karl Taylor Compton Prizes.

RESEARCH

Professor Mark Cane has been studying the response of the low-latitude oceans to periodic atmospheric forcing. He has obtained analytic results that account for the observed seasonal variations of the thermocline depth in the tropical Atlantic. His calculations explain the seasonal transports of heat to higher latitudes as a dynamical consequence of the seasonally varying wind stress. A novel numerical model incorporating the same elementary physical ideas has been used to investigate upwelling in the Gulf of Guinea. It indicates that the strong summer and weak winter upwelling events both result from wind changes in the remote western Atlantic.

Professor Cane also has developed a numerical model of the upper ocean incorporating mixed-layer processes, and is using it to extend his work to the influence of thermal processes. He has shown that the surface heat flux has a profound influence on the equatorial current system through its essential role in maintaining the density stratification that inhibits vertical mixing.
Professor Charney had been investigating the phenomenon of "blocking" in the atmosphere. This is the name given to the situation when a large high-pressure center becomes quasi-stationary and appears to block other systems from moving in to take its place. His work indicates that what appears to be blocking can be produced by detailed and also by highly simplified mathematical models, provided that the models are realistic enough to include topographic features of the earth’s surface.

Professor Glenn Flierl has been developing the theory of oceanic motions of horizontal scales ranging from about 100 kilometers up to the diameter of ocean basins. He has completed a number of theoretical studies of particularly intense eddies found south of the Gulf Stream, called cold-core rings. Models of the structure of these eddies, their movement, the role of nonlinearity in maintaining their strength against dispersion, and their effects on the fluid around them have been constructed. He is studying the impact of these eddies upon the biota within and around them. This work should give some insight into the degree to which biological data can be used to trace physical processes.

Professor Flierl is also involved in a large project to study warm-core rings found north of the Gulf Stream. There are some distinct differences in the dynamics of cold-core and warm-core rings, since the latter are influenced by atmospheric heat exchange and topography, and they interact strongly with the shelf water. He also is studying models of two and three dimensional nonlinear permanent-form waves which can be applied to oceanic flows such as rings or smaller-scale eddies, or to atmospheric phenomena. Finally he is continuing efforts to understand the impacts of pollutants which are biochemically degraded. Models have shown that it may be difficult to predict safe rates of disposal of such wastes in the ocean; impacts can be quite small until a threshold is passed, at which point the biota die out suddenly and will recover only if the disposal rate is reduced far below previous levels. This work is applicable to waste disposal currently occurring in deep-water dumpsites.

Professor D. Edmunds Harrison is continuing work on several fronts to try to understand the dynamics of the long-time averaged ocean circulation and, in particular, the roles played by mesoscale turbulence in this circulation. A serious shortcoming of contemporary models that attempt to account for the ocean circulation is that their results are often extremely sensitive to how motions unresolved by the computational grid are parameterized into some type of model "friction." He has made significant advances in explaining the sensitivity found in the models in terms of basic physical constraints. Also of potentially major importance is the hypothesis that the principal subtropical and subpolar gyres of the ocean attain vorticity equilibrium through the meridional transport of eddy relative vorticity by meandering Gulf Stream-like currents. This type of behavior has been observed in numerical model oceans, and is the leading proposed equilibrium mechanism for the ocean that does not require major departures from geostrophic dynamics.

Professor Edward Lorenz has constructed a nine-variable, primitive-equation model which possesses an energy invariant, and which is considerably simpler than other low-order models with this property. With forcing and dissipation added, the model can be run without blow-up. He has found that with weak forcing, gravity waves do not occur in the model except as initial transient phenomena, but, with strong forcing, they are permanent features. The attractor sets in the weak-forcing and strong-forcing cases are being compared.

Professor Lorenz also has formulated a low-order model which incorporates the presence of water vapor and liquid water in the atmosphere. He has found that the water, through a cloud-albedo feedback, makes possible a new form of intransitivity, where either a cold regime or a warm regime can become permanently established.

Professor Erik Mollo-Christensen has developed a new method of estimating sea-surface currents from satellite images, in regions of high current shear. The method is based on the assumption that the semidiurnal lunar tide excites shear-flow instability waves, and that one can then use the dispersion equation for barotropic shear instability to estimate the current. The method is in the process of further verification.

In cooperation with Dr. A. Ramamonjiasa of Institut de Mecanique Statistique de la Turbulence, Professor Mollo-Christensen has carried out wind-wave generation experiments, which show that the feedback effect of wave generation on the wind profile is important, and will have to be included in future formulations of wave generation by wind. Finally, he has found that although
fourth- and higher-order effects in nonlinear sea-surface wave dynamics may be unimportant locally, these effects produce irreversible shifts of energy to lower frequencies, which eventually dominate the wave field.

Professor Reginald Newell and his colleagues recently have completed a study of phase relationships in the Southern Oscillation phenomenon, based on 100 years of Pacific sea-surface temperature. Changes occur first in the western North Pacific, then in the eastern equatorial Pacific, and finally in the central equatorial Pacific. These last changes may be due to westward propagation of sea-surface-temperature anomalies, and may account for the previous finding that tropical air-temperature changes follow changes of sea-surface temperature in the eastern Pacific by several months. Professor Newell also has assembled evidence that transfer of tropospheric air into the stratosphere occurs mostly in the tropical west Pacific region and in the Asian summer-monsoon region. These stratospheric regions may be sensitive indicators of tropospheric circulation processes.

Professor Richard Passarelli and graduate student Kenneth Lo are continuing their study of snow growth in winter storms. Using laser imaging probes aboard an Air Force Geophysics Laboratory instrumented C-130, and a unique flight plan designed to follow a region of falling snow, they have demonstrated that the sequence of physical processes of snow growth can be observed in the natural atmosphere. The observations are currently being compared to results from their theoretical models of snow growth, and suggest the rather unexpected finding that particle breakup is very important in shaping the size distribution of snow.

Under the direction of Professors Passarelli and Frederick Sanders and Research Engineer Spiros Geotis, the Weather Radar Laboratory is initiating multiple Doppler radar and aircraft studies of New England winter storms. The kinematic and thermodynamic structure of mesoscale precipitation bands can be obtained from the radar and aircraft measurements, which offer the best clue to the mechanisms of formation of these features. The Doppler radar processor, designed and built by Alan Siggia of the Weather Radar Laboratory, represents the new state-of-the-art for weather-radar signal processing. The system is built around a discrete Fourier transform processor which will permit accurate ground clutter rejection for observing winds in weak, low-level winter storms. The Laboratory also is working with the Lincoln Laboratory in the evaluation of the NEXRAD system -- a nationwide system of Doppler radars to replace the current non-Doppler weather radar network. The work involves radar data collection in summer convective storms, with the aim of determining how Doppler radar data can be used to aid air traffic control in the vicinity of dangerous thunderstorms.

Professor Raymond Pierrehumbert is currently engaged in a program aimed at elucidating a number of aspects of the influence of topography on atmospheric motions. The interaction between meso-scale and synoptic-scale events is receiving special attention in these investigations; one such topic involves the possible role of inertia-gravity waves in triggering upper-level cyclogenesis in the lee of mountain ranges. Mountain-induced frontogenesis, orographic instability, and frontal instabilities are also under investigation. In addition to analytical work in the above areas, a two-dimensional, numerical mesoscale model and a general code for determining the three-dimensional stability of two-dimensional flows involving topography are being prepared. The theoretical research is coordinated with the ALPEX field program, an international experiment designed to provide data on cyclogenesis and other mountain-induced phenomena in the neighborhood of the European Alps. The data set to be generated by ALPEX will have unprecedented resolution, and for the first time will make it possible to test a number of extant theories of lee cyclogenesis. Professor Pierrehumbert also is investigating the structure and stability of coherent vortices, and various mathematical and physical aspects of stability theory.

Outputs from the three-dimensional, dynamical-chemical model of the upper atmosphere developed by Professor Prinn and his collaborators are presently being used to infer the Lagrangian-mean circulation of the upper atmosphere and to study the global chemistry and dispersion of methyl chloroform and fluorocarbons. An improved method for calculating radiative heating also has recently been incorporated into this model. The expanded version of this quasi-geostrophic model, which has increased horizontal resolution and contains some 40 chemical reactions, will have its first production run in the near future.

Measurements have now been taken for three full years by Professor Prinn and his collaborators in the Fluorocarbon Atmospheric Lifetime Experiment, which comprises five globally distributed automated ground stations (in Ireland, Oregon, Barbados, Samoa, and Tasmania) taking roughly
six-hourly measurements of CFC$_1_3$, CF$_2$Cl$_2$, CH$_3$CCl$_3$, CCl$_4$, and N$_2$O. All these species decompose in the stratosphere, leading to ozone destruction. The principal aim is to determine the atmospheric lifetimes of CFC$_1_3$ and CF$_2$Cl$_2$.

Professor Rizzoli has been studying water masses, and in particular the formation of dense deep water in winter time, and has been constructing dynamical models of the processes involved. She also is investigating the properties of nonlinear permanent wave solutions of model equations suitable for describing large-scale motions in the ocean and the atmosphere. Her interest is focused on the predictability of these coherent flow fields, when flow configurations undergoing turbulent evolution are superposed.

Professor Sanders, in collaboration with Drs. K. Saha and J. Shukla, has demonstrated that monsoon depressions, an important type of tropical cyclone that forms in summer over the head of the Bay of Bengal, are a response to weaker but previously identifiable westward-moving disturbances at upper levels over southeast Asia. A number of these disturbances represent residuals of earlier typhoons in the South Sea. In a numerical simulation study of a uniquely well-observed monsoon depression which occurred in July 1979, Professor Sanders has found that the physical mechanisms whereby the storm propagated and produced much of its rain were the same as those which operate in cyclones of higher latitudes. The origin of the intense inner core of the storm and its maintenance against surface frictional dissipation, however, could not be accounted for by these large-scale mechanisms. In these respects the monsoon depression resembles the true tropical cyclone, and evidently depends crucially on the large-scale effect of organized cumulus convection.

In a study with Professor L. F. Bosart of the State University of New York at Albany, Professor Sanders showed that a persistent mass of organized flood-producing convection, migrating eastward across the north central and northeastern United States during July 1977, resembled a tropical cyclone in its wind and temperature structure, except that it lacked the intense core and the warm surface boundary layer of the oceanic counterpart. When the overland storm moved over a warm water surface, a vigorous cyclonic circulation quickly developed in the boundary layer. This behavior, believed typical of many convective storms over North America, suggests a greater predictability than has hitherto been thought to characterize convective storms other than cyclones of tropical origin.

Professor Peter Stone and his collaborators at NASA's Goddard Institute for Space Studies have completed the development of parallel two-dimensional (2-D) and three-dimensional (3-D) models of the atmosphere, for use in climate research. The 2-D model contains more physics than previous 2-D models, including a representation of longitudinal variations of surface winds, which is crucial to a realistic simulation of the atmosphere-ocean interaction. The 3-D model is an order of magnitude more efficient with respect to computer time than previous 3-D models. They also have continued to analyze the data coming in from their photopolarimeter experiment on the still-active Pioneer Venus Orbiter. The data continues to reveal new long-term changes in the circulation and structure of the upper Venus atmosphere.

Professor Stone also has continued his studies of atmospheric heat fluxes. During the past year he and his students have analyzed a large sample of middle-latitude winter data to determine how the large-scale eddy fluxes and the temperature field behave on short time scales. They have found that the behavior can be described by a fairly simple model which agrees closely with only one of the many theoretical models that have been developed in recent years. They also have discovered that the non-eddy processes modify the latitudinal temperature structure in the surprisingly short time of about one day.

EDWARD N. LORENZ
Department of Nutrition and Food Science

During the 1980-81 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 faculty members of the Department are described in the publication Faculty Research Summaries, which is available in Department headquarters.

EDUCATIONAL ACTIVITIES

Graduate Degree Programs

In the 1980-81 academic year, a total of 152 candidates for graduate degrees were enrolled in the five graduate degree programs offered by the Department: metabolism and human nutrition; food science; biochemical engineering; toxicology; and neural and endocrine regulation. Twenty Ph.D.s were awarded during this academic year. Masters of Science were awarded to 26 students.

Undergraduate Programs

Enrollment in the undergraduate curriculum in Applied Biology (Course VII-B) in the 1980-81 academic year was 35, distributed among 10 seniors, 13 juniors, and 12 sophomores. Faculty and staff members continue to participate actively in several other facets of Institute undergraduate programs. Currently, the Department provides a total of 12 freshman advisors from among its faculty, technical and administrative staffs, and graduate students. During the academic year, there were 124 students enrolled as UROP participants in the Department (51 in the fall term, and 73 in the spring). Members of the Department faculty also offered eight undergraduate seminars and acted as premedical advisors for 25 undergraduate students.

CONFERENCES AND SYMPOSIA

The Eighteenth Annual Underwood-Prescott Memorial Symposium was held on September 23, 1980, to honor the awardee, Albert C. Hersom, in recognition of his contributions to food science in general, and outstanding work in food microbiology, in particular. Mr. Hersom presented the memorial lecture on the subject "Developments and Problems in Food Science and Technology."

In October 1980, MIT sponsored a conference addressing the status and prospects of biotechnology. The symposium evolved as a result of the collaboration between MIT and F. Eberstadt & Company, Inc. in a research effort related to the Office of Technology Assessment report on applied genetics. The conference was chaired by Professor Anthony J. Sinskey of this Department, and involved the participation of a large number of faculty members from this and other MIT departments. It brought together over 500 representatives of industry, academia, and the financial community. The foci of the conference were: 1) recent advances in life science technology of scientific and commercial importance; 2) significant gaps in the application of scientific understanding and engineering capabilities in development of new products, including drugs; and 3) as a result of #2, the time required to commercialize new products and processes derived from biotechnology has been generally underestimated by the public, the financial community, and many companies. Individual session topics included:

- the role of molecular biology in biotechnology
- enzyme, fermentation process and biochemical engineering
- current issues in biotechnology
- application of biotechnology
- application of biotechnology to the health-care industry
- application of biotechnology to agriculture and chemicals
- business and development strategies for biotechnology
FACULTY

Dr. John M. Essigmann was appointed an assistant professor of toxicology, effective January 1981. Dr. Essigmann received his Ph.D. from MIT and was a research associate in toxicology until his appointment to the faculty. His research interests are in the area of mechanisms of mutagenesis and carcinogenesis.

Dr. Marsha Rosner received an appointment as an assistant professor of toxicology, to become effective in January 1982. During the preceding six-month period, Dr. Rosner will be an instructor in toxicology. Dr. Rosner received her Ph.D. in chemistry from MIT, and has been a postdoctoral fellow in the Department of Biology. Her research interests are in membrane structure and biochemistry, particularly as regards the effects of toxic agents such as carcinogens and tumor promoters on cellular membranes.

Dr. R. Alan North will become an associate professor of neuropharmacology in July 1981. He received his M.B. and Ph.D. from the University of Aberdeen, Scotland, and was an associate professor of pharmacology at Loyola University Medical School prior to joining our faculty. His research interests include neurophysiology, autonomic physiology, and neurotransmitter substances. Dr. Carolyn F. Craft will become an assistant professor of comparative pathology (joint with the Division of Comparative Medicine), effective July 1981. Having received her D.V.M. from the University of Georgia, she recently completed residency training in comparative pathology at the Johns Hopkins School of Medicine. In addition to her duties with the Division of Comparative Medicine, she will participate in the research program in toxicology in the Department.

Dr. Robert S. Langer was promoted to associate professor of biochemical engineering.

Two resignations of faculty members were effective during this academic year. Dr. Reinaldo Gomez, who was recently promoted to associate professor of applied microbiology, left MIT in May 1981, to become director of industrial microbiology of Genentech, San Francisco, CA. Dr. Michael Moskowitz, associate professor of neuroscience, resigned his position in February 1981, to become director of neurosurgical stroke research at the Massachusetts General Hospital. Richard J. Wurtman, professor of neuroendocrine regulation, took a six-month sabbatical leave in Switzerland from January through June. He spent three months at the University of Lausanne and three months in Basel working at the CIBA-Geigy laboratories.

Faculty Awards

Dr. Alexander M. Klibanov, assistant professor of applied biochemistry, was the recipient of the 1981 Henry L. Doherty Professorship. As the Doherty Professor, he is studying an enzymatic method for removing two toxic chemicals, phenols and aromatic amines, from industrial wastewaters. Dr. Michael Marletta, assistant professor of toxicology, was appointed the Institute’s first Mitsui Career Development Professor of Contemporary Technology, effective July 1, 1981.

GERALD N. WOGAN

Department of Physics

GENERAL

In 1980-81 the total number of faculty members was 93 compared to 90 in the previous year. The number of declared physics majors was 250. Full-time graduate students numbered 296, the highest since 1967. Degrees awarded during the year numbered 83 S.B., five S.M., and 36 Ph.D.

The Undergraduate Education Committee's recommendations to strengthen the atomic and quantum physics component in the basic program of all majors are being implemented, beginning with the
class of 1984. The committee is now engaged in re-evaluating the basic classical physics sequence, 8.01-8.03. Most attention is being focused on the first two semesters of this, i.e., the freshman Institute core subjects in physics.

In addition to a very successful departmental colloquium series, the program of Undergraduate Physics Colloquia organized by the Student Physics Society had another good year. There was also another in our series of all-day symposia focusing on major areas of research in the Department. This year the subject was "Recent Developments in High Energy Physics." The symposium, organized by Professor Bernard T. Feld, had as speakers the following Department members: Professors James Branson, Roscoe Giles, Alan Guth, Elizabeth Hafen, and Scott Whitaker. The Department also hosted the New England Regional Meeting of the American Physical Society in fall 1980.

This year the program of cooperation with industry resulted in eight summer research positions for our undergraduates.

The following faculty members received promotions during the year: Associate Professor Saul Rappaport was promoted to professor. Associate Professor John Joannopoulos was granted tenure. Assistant Professor Judith Bostock was promoted to associate professor.

Visiting faculty during the year included Sheldon Glashow, Kjell Johnson, Shmuel Nussinov, Ramachandra Rao Dasari, William Wing, and Pei-Yuan Zhou, visiting professors; and Alan Guth, Francois Vannucci, and Albert H. Walenta, visiting associate professors.

Leaves during the year included Thomas H. Antonsen, Jeffrey Goldstone, Lee Grodzins, Saul Rappaport, Charles B. Thorn (academic year), and Toyoichi Tanaka (spring term).

New appointments included Charles Alcock, Lennox L. Cowie, and Scott D. Tremaine, associate professors; and Prabha K. Tedrow, instructor.

Professor Bernard F. Burke was named William A. M. Burden Professor of Astrophysics.

Professor Peter A. Wolff has been named to succeed Professor Benjamin Lax as director of the Francis Bitter National Magnet Laboratory.

William E. Turchinetz, senior research scientist, was named associate director of Bates Linear Accelerator.

Professor Jeffrey Goldstone was selected by the American Physical Society to receive the Dannie Heinemann prize for Mathematical Physics for 1980. Professors Herbert S. Bridge and John W. Belcher were awarded the medals of the National Aeronautics and Space Administration for exceptional scientific achievement for their roles in the Voyager project. Professor Robert J. Birgeneau received the Yale Science and Engineering Award for Advancement of Basic and Applied Science. Professor Uno Ingard has been awarded the Rayleigh Medal of the British Institute of Acoustics.

Professor George B. Benedek was elected to membership in the National Academy of Sciences.

Professor Felix M. H. Villars was elected chairman of the MIT faculty for 1981-83.

Resigning this year were Professors Antonsen, Thorn, and George Brandenburg.

RESEARCH

Astrophysics

I. Gravity Research. The gravitational research group in the Department is continuing the development of the COBI satellite and an interferometric gravitational source antenna. The COBI satellite is now scheduled to be launched in 1987. This mission will measure the cosmic background radiation spectrum in the mm and sub-mm spectral regions, and the large-scale angular
distribution of the brightness at four wavelengths below the black body peak, and will make a study of the universe in 10 bands extending from 300µ to 1µ.

Work on the eventual detection of gravitational radiations from astrophysical sources continues. A study of a 10km system placed in a remote region of the United States is under way. An antenna of such a scale using present technology should be able to set meaningful limits upon, if not detect, the gravitational radiations from hypothesized sources.

II. Radioastronomy. Radioastronomy research has covered many areas: spectroscopy of the interstellar medium, new surveys of radio sources, and interferometric studies of a wide variety of galactic and extragalactic radio sources. Studies have been made of diffuse clouds, reflection nebulae, and the galactic center regions by observing emission from carbon monoxide in its various isotopic forms, and ammonia. Generally the diffuse clouds are believed to be the site of formation of low-mass stars, such as our sun, and reflection nebulae are clear indications of the interaction between newly formed stars and the dust cloud in which they are imbedded. The observations provide evidence that the molecular clouds are composed of many individual "clumps" with typical sizes of the order of 0.1 parsecs, and that they have gas densities of $\approx 10^4$ cm$^{-3}$ and temperatures of $\approx 10-30$K.

Work is continuing on a radio source survey at 6cm using the 300-foot telescope of the National Radio Astronomy Observatory at Green Bank. The first section, including a sample of 2,530 sources, has been completed and will be published shortly. The complete survey, covering the entire celestial circle in a strip 23° wide at the equator, should be completed during the coming year, and will comprise about 8,000 to 10,000 sources, three-quarters of which have never been catalogued before. The new survey should be useful for a variety of purposes, and should include a number of new kinds of radio-emitting objects.

The interferometric work has included use of the VLA (the Very Large Array) of the National Radio Astronomy Observatory near Socorro, New Mexico, and continued exploitation of VLBI (Very-Long-Baseline Interferometer). One of the most interesting objects studied by both methods has been the twin quasar 0957+561, the first example of a cosmic gravitational lens effect. The radiation from a single quasar has been split into two images by the gravitational field of an intervening cluster of galaxies. Most of the refraction is caused by the largest galaxy in the cluster, but the combined VLA and VLBI radio data place many restrictions on the lens model. The matter responsible for the refraction cannot reside in the stars observed in the principal galaxy and the associated cluster. There must be a new component of "dark matter," comprising most of the mass of the system, which influences the proportions of the gravitational lens in a critical way. Such dark matter in galaxies and clusters of galaxies has long been suspected from indirect evidence, but the gravitational lens observations demonstrate its presence in a convincing way.

III. X-ray Astronomy. During the past year, studies based on the SAS-3 satellite of X-ray pulsars, X-ray bursters, and the X-ray emission of a radio galaxy have been published. The structure of one low-mass binary, the pulsar 4U1626-67, has been found to be "highly compact" and therefore the companion cannot be a normal star, but must be either a black dwarf (a star which, as a result of its small mass, never ignited hydrogen fusion) or a degenerate white dwarf (a star which is the remnant of thermonuclear fusion). Further study of the enigmatic Rapid Burster revealed a new kind of Type II burst characterized by durations as long as several minutes in contrast to a typical duration of 15 seconds. Type I (thermonuclear) bursts from three different X-ray sources have been found to have characteristic dips in their burst light curves at energies about 10keV, giving the appearance of double bursts. The effect may be the result of Compton scattering. A map of the outer radio lobe region of the radio galaxy Cen A placed an upper limit of $2.5 \times 10^{-11}$ erg/s on the lobe X-ray emission, in contradiction of previous results. The corresponding lower limit on the average magnetic field in the lobes was found to be 1.6 microgauss, in agreement with electron/proton equipartition.

IV. Theoretical Astrophysics. The MIT theoretical astrophysics group has undergone a major expansion during the past year, with the addition of three new faculty members and one principal research scientist, plus other supporting staff. The research work of the past year has included an exhaustive study of thermonuclear processes on accreting neutron stars, a detailed analysis of the ionization equilibrium in the diffuse medium that produces spectral emission lines in quasars, and a theoretical investigation of gamma-ray emission by radio pulsars.
Atomic, Condensed Matter, and Plasma Physics

I. Atomic Physics. The behavior of Rydberg atoms in strong magnetic fields has been studied. Both experimental and theoretical evidence was obtained for systematic symmetries in the energy-level shifts produced by the magnetic field. The production and absorption of black body radiation by Rydberg atoms have also been studied, and photoionization at radiation temperatures of 100 - 300K has been measured.

Work continues on the production and study of spin-polarized hydrogen, which remains a gas of separated atoms down to the absolute zero of temperature. Scientifically, this substance is of interest because at higher densities it may exhibit a new state of matter -- a superfluid gas. Technologically, this material is of interest because of its high energy content (200 times the energy per unit mass of dynamite) and its potential for producing high density spin-polarized proton sources and targets for accelerators.

II. Condensed Matter Physics. A major area of interest is the study of phases and phase transitions in two-dimensional systems formed on solid surfaces. It is now believed that thermally excited fluctuations, the symmetry of the ordered phase, and the number of space dimensions determine the condensed phases that can exist, and in particular that only liquid and gas phases are possible in a two-dimensional system. Research on such questions is being done with liquid crystals and with monolayers adsorbed on solid surfaces. One important research technique in this field is the study of surface structures with X-ray synchrotron radiation, and the major portion of funding has been obtained for a joint MIT/IBM beam line, with two spectrometers, at the National Synchrotron Light Source at Brookhaven National Laboratory.

The possibility of using cheap non-crystalline material for electronic device fabrication involves fundamentally interesting problems in physics. Theoretical and experimental studies have been made on the behavior of amorphous semiconductors, including computational methods for solving the Schrödinger wave equation in random potentials. Recent experiments have led to a simple but accurate description of the motion of photoexcited electrons in amorphous semiconductors and an understanding of how to achieve longer carrier lifetimes. It is hoped this program will lead to improved efficiency in amorphous solar cells, which in principle offer enormous economic advantage over existing types of cell.

The phenomenon of two-photon absorption has been observed in InSb, in an applied magnetic field, using cw CO2 lasers at power levels down to about 10mW. This was the first observation of two-photon absorption in solids using only cw lasers, and provides the opportunity to study this phenomenon at high resolution. Also, for the case of two-photon absorption in zincblende semiconductors (in zero magnetic field), calculations have shown that exciton effects are important and that the tunneling theory is incorrect in the nonparabolic region.

In a joint project with the Honeywell Electro-optics Operations Advanced Technologies Group, a combined theoretical and experimental program is under way to investigate the detectability of the magnetic vector potential by means of Josephson superconducting devices. The results, if positive, would be of interest in practical problems of signal propagation and related devices.

III. Plasma Physics. Work with MIT's tokamak device Alcator C has continued, and during this year achieved a new world record for Ne -- the value 3 x 10^13cm^-3 sec at toroidal fields of Bt = 10T. On the basis of this result and a general advance in theoretical understanding, it is believed that a small, high-field tokamak of the Alcator type might achieve ignition in the near future. Substantial progress has also continued with basic plasma physics using Versator II (research tokamak) and Constance II (research mirror).

IV. Biomedical Physics. Studies of diseases of the eye have continued. Quasi-elastic light scattering has been used to develop an immunoassay system as sensitive as the radioactive system currently used. The fundamental theory of phase transitions (see II above) has been applied to the phenomena of cataract formation and retinal detachment.

Percolation theory and the theory of stochastic processes have been applied to the problem of electrical instability of the heart -- which results in fibrillation and sudden death in heart attacks. A computer simulation of a theoretical model has features corresponding to many of the observed effects. Experimental work (on dogs) is proceeding.
Nuclear Theory

I. Electromagnetic Interactions in Nuclei.

- precise determination of the nuclear charge distribution arising from the one-body proton density, starting from elastic electron scattering and mesonic X-ray data, and including corrections for neutron form-factor, spin-orbit contributions, relativistic effects, exchange currents, and angular momentum projection. Extraction of the nucleon momentum distribution from high energy electron inelastic scattering
- calculation of various electron scattering form factors, including some for very high spin states in heavy nuclei, by joining together the study of meson-exchange currents and that of particle-hole excitations
- the role of the $\Delta$ isobar in intermediate energy photon-nucleus interactions
- deep inelastic electron scattering in the quasi-elastic and in the $\Delta$-excitation regions
- photo-production and electro-production of hypernuclei by the ($\gamma$,K) reaction
- model dependence of deuteron photodisintegration, especially with respect to recent unexpected experimental results for forward and backward proton angles
- thorough analysis of the sensitivity to model form factor and meson exchange current effects of elastic $e + d$ scattering at all momentum transfers

II. Nuclear Reactions.

- study of charge-changing and neutral current neutrino disintegration of deuteron. Analysis of the cross sections both at reactor energies and at the energies appropriate to LAMPF
- the relevance of pion scattering and high energy proton scattering to the determination of nucleon distributions in nuclei
- doorway state description of pion interactions with nuclei, and its use in extracting information about $\Delta$-nucleus interactions
- interaction of relativistic protons with nuclei, with emphasis on the excitation of the incident proton and its subsequent decay, most of which appears to occur outside the nucleus
- critical analysis of the scattering of 1GeV protons by He$^+$
- pion absorption and sub-coulomb stripping deuterium
- further work on the pure resonance model of ($\gamma$,p) reactions in the giant dipole region

III. Nuclear Collective Motion.

- the time-dependent mean field (TDMF) approximation has been successful in many applications, including fusion reactions, deep inelastic collisions, pion condensation in heavy ion collisions, and particle problems. Corrections and extensions have been worked out which resolve the ambiguities of its special case, the time-dependent Hartree-Fock approximation.
- incorporation of many-body correlations and collision terms in TDMF, in view of high energy applications
- process-dependent TDMF, calculation of particular matrix elements of the time-evolution operator, and application to the many-body S-matrix
- periodic solutions to the TDMF equations describing large amplitude collective states. WKB quantization of this gives very good results in simple models
- tunneling and spontaneous fission described by TDMF with imaginary time
- mean field study of the nuclear partition function and level density, including the RPA corrections
- TDMF at finite temperature, with application to compound nucleus fission
- semi-classical analysis of the interacting boson model, and clarification of the geometrical properties of these motions
work has also been done on the Born-Oppenheimer approach to nuclear collective motion. This fully quantal method leads back to the adiabatic time-dependent Hartree-Fock theory in the classical limit. The method has been applied to nuclear rotations, particularly the electromagnetic transition form factors between rotational states, and to the coupling of collective motion to intrinsic excitations.

IV. Nuclear Structure. Variational techniques have been used to understand the convergence of the usual perturbation theory of nuclear matter and to obtain further insights into the physical mechanism of saturation. Effective interactions have been designed to simplify nuclear structure calculations (including particle-hole matrix elements as well as binding energy systematics), and theoretically derived interactions have been compared with phenomenological ones. Numerous microscopic calculations have been performed on spherical nuclei, deformed nuclei, neutron stars, systematics of ground state and single-particle energies, Coulomb energy differences in mirror nuclei, and isobaric analogs.

V. Nuclear Forces. Studies have been made on the following:

- the contribution of the \( \sigma \) meson to nuclear forces. Effect of its strong coupling to two pions and removal of a ghost pole
- extension of low-energy theoretical models to include recent experimental information on the nucleon-nucleon interaction at intermediate energies, especially relative to isobar production
- model independent analysis of a \( \pi^- p \rightarrow \pi^+ n \) experiment. Extraction of the \( \pi \pi \) scattering length and the symmetry-breaking constant \( \xi \), with extrapolation to threshold. Joining the short range quark description and the long range hadron exchange description of hadron-hadron forces. A boundary condition at about 1 fm seems to allow parameter-free predictions for strong interactions over a broad energy range with moderate accuracy
- calculation of "single quark states" in a spheroidal cavity. Construction of the gluon propagator. The energy of an n-quark bag as a function of volume and deformation. Application to the description of baryon resonances in terms of rotational bands. Application to the short-range nucleon-nucleon force as arising from the fission-fusion of a 6-quark bag

Particle Theory

The emphasis of the research in the past year has been on gauge theories of strong and electroweak interactions. Efforts may be broadly classified as follows: a) structure of gauge theories; b) quantum chromodynamics; c) the nature of the Higgs field; d) consequences, especially cosmological ones, of grand unification. These are described more fully below.

I. Gauge Theories.

- The lifetime and branching ratios of proton decay modes were calculated in various grand unification schemes. These furnish information on the nature of the grand unified group and the pattern of flavor masses and mixings.
- Some cosmological predictions in the SU(5) grand unified model have been obtained. They pertain to times during the first \( 10^{-37} \) seconds after the big bang. As the universe cools through \( kT \approx 10^{13}-10^{14} \text{GeV} \), it undergoes two successive phase transitions. Superheavy (\( M \approx 10^{15} \text{GeV} \)) magnetic monopoles would be produced at the second phase transition. The consequences of extreme supercooling are being investigated.
- Monopole and multi-monopole solutions have been studied by exploiting symmetry properties and by numerical methods.
- In earlier work done here, it was shown that soliton solutions in a non-Abelian gauge theory may possess fractional "charge" (e.g., fermion number). This idea is being applied to the possibility of fractional electron number in solid-state physics.
- The phase structure and the confinement aspects of gauge theories have been studied via various different approaches: high temperature expansion, lattice formulation, and the \( 1/N \) expansion.
II. Quantum Chromodynamics (QCD).

- A more realistic bag-model description of the pion was devised.
- A proposal was made that QCD might be replaced by a theory which accommodates the existence of free fractionally charged quarks, but agrees with QCD where the latter has been successfully tested experimentally.
- A heuristic picture of the QCD vacuum has been put forth, involving a gluon condensate with special properties. This picture leads to suggestions for the glueball spectrum, and for the mechanism of confinement, and points the way to a more quantitative study now underway.
- Structure functions in deep inelastic scattering were studied with a view of gaining more physical understanding.

III. Higgs Field. It was shown that the Weinberg-Salam model without Higgs fields can generate mass spontaneously, through a mechanism analogous to the generation of the energy gap in superconductivity. A mass sum-rule was obtained, yielding an estimate of 48 GeV/c² for the mass of the top quark. In this picture, the Higgs field plays the role of phenomenological order parameter.

It was shown that there are vortex-ring excitations in the Weinberg-Salam model, in which one quantum of the Z meson is trapped in a torus, inside which the Higgs field is expelled. Called "vorticons," they have a mass estimated by a variational calculation to be 3000 GeV/c².

Studies in the grand unified theory referred to in I. suggested a lower bound on the effective Higgs mass of 9 GeV/c².

Investigations were initiated to see if the Higgs fields (and concomitantly, the particle masses) might be low-energy manifestations of the fact that space-time has higher dimensionality than four. The approach is an extension of the works of Kaluza (1921) and Klein (1926) in the context of general relativity in high dimensions.

IV. Grand Unified Models. A grand unified model was constructed, based on the gauge group $[0(10)]³$, which had, in addition to two families of ordinary fermions, an SU(4) technicolor group. The new feature of this model not seen in previous models is that extended technicolor, which gives rise to small masses for the ordinary fermions, emerged in a natural fashion as a consequence of a new stage of dynamical symmetry breaking, beyond that of the electroweak but far below the grand unified scale. As was to be expected, the model manifested problems typical of most technicolor theories.

Also studied were alternatives to the usual "Pati-Salam" scheme of quark-lepton unification at moderate energies. This unification is necessary in order to give masses to the axions that show up in technicolor theories. One scheme was SU(5)-like (but avoided baryon decay), but giving mass to only one of the two axions. In another scheme, the Pati-Salam SU(4) was replaced by a chiral SU(4)xSU(4) and both axions still acquired mass. Interestingly, the chiral nature of the lepto-quark currents led to cancellation of the lowest order contributions to these masses, and thus to much lighter axions.

V. Other Topics.

- The relativistic string model in higher dimensions has been investigated.
- Cosmological consequences of massive neutrinos were considered.
- The stability of quark stars was investigated.
- Knowledge of hadronic structure gained from the bag model has been utilized in a method that enables one to make predictions in low-energy hadron-hadron collisions.

Experimental Nuclear Physics

I. Heavy Ion Group. This group is engaged in studying the reaction mechanisms and specific reactions involved in collisions between complex nuclei involving energies in the range of a few hundred MeV -- i.e., some 10 MeV per nucleon. Such interactions, only somewhat above the
Coulomb barrier, probe the properties of nuclear matter in bulk, as well as quasi-molecular combinations of strongly bound nuclei. Of particular interest are reactions resulting from the fusion of such heavy combinations as Ni$^+$ + Ni, and the role of "valence" neutrons, e.g., in the comparison of $^{58}\text{Ni} + ^{58}\text{Ni}$ with $^{58}\text{Ni} + ^{64}\text{Ni}$. These experiments are, perforce, performed at accelerators at various national laboratories such as Brookhaven, Oak Ridge, and Berkeley.

II. Bates Linear Accelerator. This accelerator has become a world-wide center for research in medium energy nuclear physics. Naturally, MIT groups, consisting of members of the Bates staff, professors from our Physics Department and their students -- both graduate and undergraduate -- play an important role in this program. In particular, the available electron, proton, and pion spectrometers are being widely utilized in the study of nuclear structure functions via a variety of probes.

Considerable thought is now being given to the needs for and possible nature of the next step in the national program in medium energy nuclear physics. Design studies are under way for a high-intensity, essentially 100 percent duty cycle machine of variable energy up to a few GeV, and for the kinds of facilities and instrumentation that will permit its optimal utilization.

Experimental Particle Physics

I. Counter Spark Chamber Group. The large, international enterprise for the construction of a versatile particle spectrometer detector facility at the Fermilab is now finally in a position to permit the taking of data. Our group's primary interest is in using the neutrino probe to study both weak interactions and nucleon structure. Towards this end, a flash tube proportional chamber directional calorimeter detector has been constructed and installed at the Spectrometer, and significant data are anticipated for the summer of 1981.

II. The Accelerator Physics Collaboration (APC). This collaboration continues to pursue the study of strong interactions -- in particular the detailed predictions of QCD (quantum chromodynamics) -- by use of hybrid systems of bubble chambers, spark chambers, proportional counters, etc. Also of interest are attempts to observe directly the decays of B- and F- particles and other manifestations of heavy (charm and upsilon) quarks. Most of this work goes on at Fermilab, but a major effort is also being mounted at the Stanford Linear Accelerator (SLAC), utilizing the recently produced polarized photon beam of energy 20 GeV/c.

III. Electromagnetic Interaction Group. Although the Mark J detector, installed at the PETRA storage rings at the DESY (Deutsches Elektron Synchrotron) accelerator, is being used in a variety of experiments at c.m. energies up to around 37 GeV, the major interest of the group has been in exploring in detail the predictions of the Glashow-Weinberg-Salam theory of the unified electro-weak interactions. In the process, the limits of quantum electrodynamics have been pushed to distances around $10^{-16}$cm; the search for the "top" quark, as well as new heavy leptons, has been extended to a mass of around 17 GeV. Experiments at the CERN intersecting storage rings have studied the strong production of J and upsilon quarks, and the nature of the Drell-Yan mechanism for the production of u-pairs, as well as other aspects of QCD.

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 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.
During the last six years (1975-81) the Course XXV faculty committee also supervised an experimental graduate program leading to the Master of Science in Interdisciplinary Science. A total of 42 students have completed this program in such areas as Animal Cell and Tissue Culture Science, Environmental Chemistry, Science Communication, Science Education, and Biomedical Science. The cumulative rating of these graduate students was 4.6 and the contents of several theses have been published in scientific journals. We feel that, overall, this program has provided opportunities and the possibility of goal reorientation for many students who have been able to register for an S.M. through this particular academic channel.

In September 1980 the Course XXV committee applied for permanent status for its graduate program. After thoughtful consideration by several review groups at the Institute, the Course XXV committee decided to withdraw its application and to discontinue its graduate option. The undergraduate program remains intact, however, and graduate students still in the program will have the current year to complete requirements for their degrees. The reason for this action stems from strictures on financial resources at MIT which make it unlikely that Course XXV could expect further financial assistance in the form of student assistantships, fellowships, or tuition awards. With the rapidly escalating educational and living costs and the tightening of loan sources and work-study programs, the possibility of attracting students with academic records comparable to those who entered the program earlier would be greatly decreased. Therefore, students who may wish to register for a master's degree are encouraged to apply to individual Science departments with the possibility of arranging an interdisciplinary curriculum.

JOHN M. BUCHANAN

Experimental Study Group

ENROLLMENT

The Experimental Study Group (ESG), now in its twelfth year of operation at MIT, has continued to attract students and staff who are interested in a small, informal academic community with an emphasis on individualized learning. This past year 34 freshmen (25 percent women, 20 percent international students, and 10 percent minority students) enrolled in ESG, 27 in the fall term and 31 in the spring term. This number is somewhat smaller than normal, due in part to stricter interviewing procedures adopted in response to the high number of students enrolling in the previous year. The freshmen completed an average of five subjects each term (three in ESG and two in the regular curriculum). Ninety percent of the subjects taken in the regular curriculum were not available through ESG.

Of the 55 freshmen who participated in ESG in 1979-80, 27 registered as sophomores for ESG this past year. They took an average of one and one-half subjects each term in ESG, taking the majority of their subjects in the regular curriculum. The cumulative median grade point for the 55 sophomores was higher than the corresponding figure for all sophomores at the Institute during the past year. Two transfer students also joined the ESG community to complete their Institute requirements.

ADMINISTRATION

Professor Robert Halfman returned to a half-time position as chairman of ESG after happily relinquishing his two-year role as Acting Dean for Student Affairs in April 1980. Holly Sweet was promoted to assistant director in December 1980, and has broadened her role in ESG to include co-teaching a psychology seminar, running a series of freshman weekend trips, and recruiting new staff members. Professor Halfman and Ms. Sweet continue to work in conjunction with ESG students and staff and the ESG Advisory Committee to develop and implement programs and policies for the community.
The Advisory Committee, appointed in 1979 by the Committee on Educational Policy to oversee ESG's academic affairs, presently consists of six members: Dean Robert Albery (chairman), Professor Alan Davison (Chemistry), Professor Anthony French (Physics), Professor Halfman (ex-officio member), Professor Jean Jackson (Humanities), and Professor Arthur Mattuck (Mathematics). The committee met four times during this past year to discuss policy matters. The committee recommended that humanities distribution subjects be offered whenever possible in the following three areas of humanities and social sciences: literature and writing, philosophy and linguistics, and the social sciences. Increased funding was proposed for one additional humanities staff member for 1981-82.

Professor Halfman is currently working with the Registrar's Office in setting up a computerized system for the collection and compilation of ESG statistics on student constituency and performance. This information will be used along with qualitative questionnaires distributed annually to ESG alumni to monitor the effectiveness of the program.

STAFFING AND SUBJECT OFFERINGS

Four main areas of academic pursuit were offered through ESG: mathematics, physics, chemistry, and humanities and social sciences. ESG's staff was assisted by 17 upperclass tutors (ESG alumni) who proved to be an invaluable teaching resource. The mathematics staff included Professor Warren Ambrose for the fall term, and Barry Cipra (instructor) and John Lee (graduate student) for the year. The physics staff was headed by Professor Halfman and included Professor Nathaniel Frank and Carl Gardner (graduate student). Professor Clark Stephenson assumed responsibility for ESG's chemistry offerings, teaching 5.60 and supervising 5.40 tutors, while Asif Iqbal (graduate student) ran a 3.091 recitation section in ESG in the spring term. Approximately 90 percent of the freshmen in ESG completed both math and physics subjects in ESG, while 41 percent took chemistry in ESG. Since a large number of students take 5.41 each year, plans are being made to offer 5.41 in ESG for the coming year.

The humanities program enjoyed an active year under the guidance of Dr. Janet Murray (research associate) and Leslie Burkholder (graduate student in the Philosophy Department). Professor Stephan Chorover assisted in the teaching of a psychology seminar in the spring term. Sixty-seven percent of the freshmen completed one or more humanities subjects in ESG, a much higher percentage than in the previous years. Subjects taken for credit included Philosophy, Logic, Psychology, Fantasy Fiction, Freedom and Authority, International Affairs, Introduction to Fiction, Writing Workshop, and several independent study projects.

In addition to these four areas, an undergraduate seminar on the applications of appropriate technology was offered for credit at ESG. The seminar, designed by William Doherty (Class of 1984) and sponsored by Professor Halfman, investigated the possibilities of improving energy conservation and developing alternative energy systems for the ESG facility.

COMMUNITY ACTIVITIES

Community activities at ESG have always been an important part of the program, and this year was no exception. In addition to the usual informal activities, two organized activities were of particular interest. Weekly luncheons with guest speakers (including Professor B. F. Skinner from Harvard University) attracted about 20 community members each Friday throughout the year. Seventy-five percent of the freshmen and their staff advisors participated in a series of five weekend trips to New Hampshire in the fall. Based on the enthusiastic response from participants, the trips will be repeated next year.
OVERVIEW

We have seen the goals of freshmen joining ESG change over the past years. Freshmen have become increasingly more concerned with finishing Institute requirements, taking as many subjects as possible during their first year, establishing themselves in a discipline early in their academic careers, and choosing an engineering major rather than one in mathematics, science, or humanities and social sciences. ESG has successfully accommodated these shifts in perspective among its students, and continues to provide an opportunity for self-motivated freshmen to pursue their goals in a flexible academic setting which can be responsive to their individual educational needs.

ROBERT L. HALEMAN
HOLLY B. SWEET

Clinical Research Center

The MIT Clinical Research Center (CRC) is an Institute resource established for the support and care of subjects or patients participating in research studies conducted by MIT investigators. Its purpose is to facilitate and enhance research in human health and disease under optimum conditions of care. The past year continued to be highly productive. Research studies conducted at the Center involved 3,693 inpatient days and 1,418 outpatient visits under 32 different research protocols. Over 45 scientific articles were published and accepted for publication as the result of work associated with the Center. Bed occupancy averaged 119 percent.

The CRC has continued under the direction of Nevin S. Scrimshaw, program director; Ranjit Chandra, associate director; and William Dietz, assistant director; John N. Udall, M.D., Ph.D. was appointed assistant program director in November 1980. Patricia Anderegg replaced Hilary Spence as administrator in August 1981, and Ms. Rita Tsay assumed the position of chief research dietitian in September.

Research activity involving outpatient volunteers continued to increase during the past year. Extensive research using variations of the primed constant infusion of amino acids labeled with stable N or C isotopes to study protein and glucose metabolism in a variety of patient subgroups has continued on an outpatient basis, placing increased demands on the two-bed infusion room. In response to this pressure two additional beds for infusions were added.

MIT departments using or potentially using the CRC include Nutrition and Food Science, Medical, Chemical Engineering, Mechanical Engineering, Biology, Psychology, and the Arteriosclerosis Center. The CRC's wide variety of research protocols and multiple observations per patient place heavy demands on its specialized computing facility currently based on a PDP 12. A new PDP 11/44 computer has been purchased to provide support for the CRC staff and investigators.

Physicians participating in the human nutrition and metabolism doctorate training program in the Department of Nutrition and Food Science, in collaboration with four area hospitals, utilized CRC facilities to initiate new research protocols and to participate in ongoing projects supervised by senior investigators and faculty. During the past year, 16 physicians, representing the specialties of internal medicine, surgery, and pediatrics, were active in the program. Their research interests included adolescent obesity, exercise and diet, total parenteral nutrition for premature infants, and the effect of early nutrition on gastrointestinal development. Following their training, physicians in this program have entered academic medicine mainly in clinical departments of medical schools or hospitals. They are responsible for an increasing number of effective programs in clinical nutrition training, research, and patient care.

The CRC also provides research support to visiting physicians and scientists including a number of fellows in the World Hunger Program of the United Nations University (UNU). Over the past year UNU fellows from Lebanon, Argentina, Turkey, and the People's Republic of China were actively involved in studies at the CRC.
Both Drs. Dietz and Udall each received two-year awards effective July 1, 1980 and April 1, 1981, respectively, as clinical associate physicians at the CRC. Dr. Dietz will continue his research on adolescent obesity, a major health problem in the United States. To date his data suggest that protein and carbohydrate diets are better for long term dietary therapy than iso-caloric isonitrogenous protein and fat diets. Further work is in progress to clarify the metabolic mechanisms responsible for these differences. Dr. Udall will apply non-invasive techniques to study the effect of human breast milk and proprietary formulae on gastrointestinal development in infants. His studies are designed to define changes in gastrointestinal absorption of nutrients over the first eight months of life and to determine if there are differences between breast-fed and formula-fed infants. The data will also be of value in evaluating pathological disorders of intestinal function in infants.

Studies under the direction of Professor Vernon Young have continued to explore protein and amino acid metabolism in healthy adult subjects and its response to dietary factors using stable isotope tracers. With these techniques he has demonstrated that mechanisms associated with the maintenance of body homeostasis are linked to the amino acid and protein requirements of the individual. These methods promise an increased understanding of human amino acid requirements under varying conditions of health and disease. A series of studies are currently under way to establish the validity of this hypothesis.

Dr. Suzanne Corkin and her associates in the Department of Psychology have continued to utilize both the inpatient and outpatient units in their investigations of brain behavior relationships with six different subject populations: (1) veterans with penetrating head injuries sustained during World War II; (2) patients who received a neurosurgical procedure, either cingulotomy or leucotomy, for the relief of chronic pain or psychiatric disease; (3) children and adults with craniopharyngiomas, tumors that invade the third ventricular region; (4) women with Turner's syndrome, a chromosomal disorder characterized by ovarian dysgenesis, low endogenous levels of estrogens and androgens, and short stature; (5) patients with Alzheimer's disease, the most prevalent type of senile dementia; and (6) healthy elderly subjects. In trying to understand the brain mechanisms that are affected in the six different groups, they use quantitative behavioral tests to sample cognitive, sensory, and sensorimotor functions, as well as motivation. They then relate these data to concomitant morphological or chemical alterations in the brain.

The CRC sponsored a weekly seminar for students and staff open to all interested persons in the MIT community and the Boston area. Investigators conducting studies at the Center or at affiliated institutions are invited to discuss their current research projects or to present information on a subject relating to human research. These seminars were well attended by both CRC and MIT staff, and other interested personnel.

NEVIN SCRIMSHAW

George Russell Harrison Spectroscopy Laboratory

The George R. Harrison Spectroscopy Laboratory is engaged in fundamental and applied research in modern spectroscopy for the purpose of advancing our knowledge of the structure and dynamics of atoms and molecules and the properties of liquids and solids. Techniques include the use of lasers and high-resolution spectrometers.

An interdepartmental laboratory, the Spectroscopy Laboratory encourages participation and collaboration among members in the various disciplines of science and engineering. This past year there has been participation from several MIT departments including Chemistry, Physics, Biology, Electrical Engineering and Computer Science, Mechanical Engineering, and Aeronautics and Astronautics. Outside collaborations with Harvard and Boston University medical schools, Bell Laboratories, and several other nearby academic and industrial organizations have further strengthened the interdisciplinary research activities of the Laboratory. The past year has also been one of significant development of the Laboratory's facilities and organizational structure. The entire physical plant was renovated, and in March the Laboratory was dedicated to George Russell Harrison, who founded it 50 years ago. This past year was also the first complete year of operation of the MIT Regional Laser Center.
School of Science

Facility Renovation and Dedication

The Institute undertook renovation of virtually every area of the physical plant of the Laboratory and, in addition, assigned to it several hundred square feet of new space for four additional laboratories. Construction began on July 14, 1980, and was completed on March 5, 1981. The renovations included installation of air conditioning and a major upgrading of the electrical power capabilities of all laboratories to meet the needs of newly acquired equipment, installation of new lighting systems, ceiling and floor tiles, and painting of the laboratories.

Formal dedication of the Laboratory in memory of G. R. Harrison, its founder and first director and later Dean of the School of Science, took place on March 5 and 6. The ceremonies began with a dinner in honor of Betty Harrison, Dean Harrison's widow. A morning symposium, "Spectroscopy and Innovation," featured Gerhard Herzberg, Charles Townes, and Edwin Land as speakers. John Slaughter, director of the National Science Foundation, spoke at a luncheon for dedication guests and the MIT Corporation. The formal dedication ceremony was presided over by Chairman of the Corporation Howard Johnson, with remarks by President Paul E. Gray, Dean Robert A. Albery, Arthur F. Findels, director of the NSF Regional Instrumentation Facilities Program, and Michael S. Feld, director of the Laboratory and the MIT Regional Laser Center.

MIT Regional Laser Center

The Regional Laser Center, a National Science Foundation Regional Instrumentation Facility housed in the Spectroscopy Laboratory, is now in the midst of its second year of operation. The Center enables researchers from academic, industrial, and other types of institutions to pursue research in broad areas of laser spectroscopy and dynamics, to develop new types of coherent sources and techniques, and to perform diagnostic studies of various substances and materials. Its unique facilities, which include a broad range of lasers and ancillary equipment, constitute one of the largest and best equipped centers devoted to spectroscopic research. They are made available free of charge to qualified scientists and engineers from MIT and outside organizations, with preference given to those in the northeast part of the United States. Professor Feld is director of the Center and Professor Jeffrey I. Steinfeld, Department of Chemistry, is its scientific coordinator.

The physical plant and operational structure of the Center are now complete, with all the major instrumentation in place, and in March the facility was officially opened to the outside community. In its first full year of operation 23 research projects have either been completed or are in various stages of progress. Nine publications have resulted so far from work performed at the Center.

RESEARCH HIGHLIGHTS

Professor Richard C. Lord and Dr. Thomas J. Thamann, Department of Chemistry, have examined the laser Raman spectra of a number of systems of biological interest. In collaboration with Professor Alexander Rich and Dr. Andrew Wang of the Biology Department, they have obtained excellent Raman spectra of the crystalline oligomer (dC-dG)₉ by means of which Professor Rich, Dr. Wang, and their co-workers discovered the Z-form of DNA. By comparing the spectrum of this crystal with that of a high-polymeric model of DNA, poly(dG-dC), Drs. Lord, Rich, Thamann, and Wang have demonstrated that in 4 M sodium chloride solution the polymer has the Z-form. It appears that the Raman spectrum is a unique method of detecting and quantitatively measuring the amount of Z-DNA in a sample of native DNA. Drs. Lord and Thamann also have collaborated with Professor Gregory Petsko of the Department of Chemistry and his group in a study of the Raman spectra of the crystalline enzyme ribonuclease A as a function of temperature, and also on an investigation of the conformational changes in the protein calmodulin when it binds calcium.

Professor Rich, Dr. Wang, and Dr. Gary Quigley of the Department of Biology have used X-ray diffraction analysis to solve the structure of daunomycin, a drug-DNA complex widely used in the treatment of human leukemia. In crystalline daunomycin-d (CpGpTpApCpG) the DNA forms a six-base-pair right-handed double helix with two daunomycin molecules intercalated in the d(CpG) sequences. The DNA double helix is distorted in a novel manner in accommodating the drug. This structure suggests significant ways in which the drug can be modified to make it more effective.
Dr. Zhu Qing-hsi, a visiting scholar from the People's Republic of China in Professor Steinfeld's group, has recorded the vibration-rotation spectrum of the $\nu_2$ and $\nu_5$ fundamentals of CDF$_3$. The Q-branch and several sub-bands of each of these transitions have been investigated using a tunable semiconductor diode laser spectrometer in the Regional Laser Center. The Q-branch and the K-structure in several P(J) and R(J) subbands of $\nu_2$, and in several Q-branches of $\nu_5$, were resolved and assigned for the first time. Constants derived for these bands are nearly 100 times more precise than those reported in previous work. The assignments have been confirmed by infrared double-resonance experiments on selected transitions in these bands.

Professor Robert W. Field, in collaboration with his colleagues in the Department of Chemistry, Dr. Keith Cross, Dr. Hartmut Schweda, and Ms. Precila Ip, is continuing his research on the electronic structure of diatomic molecules. Various laser spectroscopic techniques have been used to characterize the electronic structure of MgO and CaO. For the first time intercombination and triplet-triplet systems of alkaline earth oxide molecules have been analyzed, facilitating state specific population probes for the lowest energy triplet states of MgO and CaO. Work on MgO is continuing in the hope of directly measuring the dissociation energy via a $^3S_1$-X $^3P_1$ transition.

Professors Field, James L. Kinsey, and Dr. Carter Kittrell, all of the Chemistry Department, have continued to refine the stimulated emission pumping technique. Experiments on I$_2$ demonstrate that it is possible to populate individual, highly excited rotation-vibration levels of an electronic ground state molecule and then to observe state-to-state energy transfer processes under single-collision conditions. Experiments are now in progress to understand how vibrational excitation energy is distributed over various bond-vibrations, whether this distribution evolves after the instant of excitation, and how collisions cause this energy to be redistributed. Molecules under study include formaldehyde, acetylene, and benzene.

Professor Feld's research in the applications of lasers to nuclear physics continues. Recent studies have centered on using single-mode laser optical pumping techniques to obtain a high degree of nuclear polarization in relatively dense samples of atomic vapors, for use target and beam nuclear physics applications. Recent experiments in sodium, ytterbium, and lithium have shown that complete Doppler coverage can be obtained by adding trace amounts of argon buffer gas to induce velocity changing collisions (vcc). Nuclear polarizations in excess of 90 percent are obtained. The physics of the vcc process are also being studied using steady-state and transient high resolution spectroscopic techniques. A test of parity non-conservation in the strong interaction is planned in the boron-10 nucleus using a dense target of polarized $^6$Li nuclei. Collaborators in this work are Drs. Peter G. Pappas and Ramachandra R. Dasari of the Spectroscopy Laboratory, and Dr. Daniel E. Murnick of Bell Laboratories.

Another new area of research, ongoing in the Infrared Laser Laboratory of the Regional Laser Center, is infrared double resonance experiments of simple molecules using a fixed frequency CO$_2$ laser pump and a tunable diode laser probe. This approach is greatly advantageous over conventional ones using fixed frequency sources because diode lasers are continuously tunable and many more transitions, directly and indirectly coupled to the pump transition, can be accessed. Molecules under study include SF$_6$, CH$_3$OH, and CDF$_3$. The work is a collaboration between Professors Feld and Steinfeld, Dr. Dasari, Dr. Martin Dubbs of the Chemistry Department, and Dr. Palash Das of Tachisto, Inc.

During the past year two studies of application of lasers to biomedical problems have been initiated. One collaboration between Dr. Wei Xiu-Bing of the Medical College of Shanghai, Dr. Geza Jako of Boston University Medical Center, and Lawrence W. Ryan, Jr., of the Chemistry Department, is studying the use of u.v. laser radiation for tumor repression in mice. Preliminary results have shown positive results which are strongly dependent on laser wavelength. In another collaboration, MIT Research Affiliate Lester Wolfe and Dr. Barry Sachs of Beth Israel Hospital in Boston and their associates have begun to study the use of laser radiation to treat atherosclerosis and other human circulatory problems.

Professor Edward I. Solomon, Department of Chemistry, continues his research on active sites in metalloproteins using laser resonance Raman spectroscopy. Intense charge transfer bands of hemocyanin and tyrosinase have been probed using this technique. Studies of copper model compounds have been pursued to obtain a definitive assignment of the relative contributions of the different active site ligands to the resonance Raman spectra of the proteins azurin and plastocyanin. These spectra differ significantly from that of stellocyanin. Studies in Rhus laccase have demonstrated that the type 3 copper site in a type 2 depleted derivative of the enzyme is reduced and
School of Science

can be reoxidized by addition of excess H₂O₂. Several resonance Raman studies have shown that a structural change occurs in the type 1 site associated with the reduction of the type 3 site. Resonance Raman investigations of anion binding in ceruloplasmin have indicated that a similar structural change may occur in this enzyme.

The spectral properties of hemerythrin, iron-superoxide dismutase and lipoxygenase are being investigated. Complete visible and UV resonance Raman studies are under way on hemerythrin and its derivatives to provide an unambiguous experimental assignment of the electronic spectral features in the 300-500nm region. Resonance Raman studies are also in progress to analyze galactose oxidase, amine oxidase, neurospora metallothionine (a copper transport protein), and formate dehydrogenase, the only enzyme known to contain tungsten.

MICHAEL S. FELD

McGraw-Hill Observatory

The 1.3-m telescope of the McGraw-Hill Observatory has been operated jointly by the University of Michigan, Dartmouth College, and MIT since 1975. It is located on Kitt Peak near Tucson. In the past, all MIT observers were members of the X-ray astronomy group. More recently, several additional observing groups from within the Department of Earth and Planetary Sciences and the Research Laboratory of Electronics have initiated ongoing programs at the McGraw-Hill Observatory. Consequently, MIT requests for observing time now exceed the time available by more than a factor of two. Therefore, starting this fall, observing proposals will be subject to peer review. It is highly likely that the increased demand for observing time and the review process will increase the quality of the science. Unfortunately, however, it will also make it difficult to secure enough time to develop new instrumentation or carry out long-term programs, particularly Ph.D. programs.

The past year's research includes the following: Professor Claude Canizares and Gerald Kriss have continued their program of optical identification and characterization of X-ray sources discovered with the Einstein Observatory. From spectra of candidates within 62 X-ray error circles, they have discovered the following optical counterparts: 26 quasars or active galactic nuclei with .03< z <.98, eight normal galaxies and two stars. The remaining X-ray sources are unidentified but have no optical counterparts brighter than seventeenth magnitude.

Professor James Elliot and his group used the McGraw-Hill Observatory in December 1980, to support their observations of an occultation of an eighth magnitude star by Jupiter which were made using the airborne Kuiper Observatory.

Dr. Robert Hohlfeld and Dr. Marc Gorenstein are making ongoing observations of temporal changes in the "moving" emission lines in SS433 at high spectral resolution. They are also making coordinated VLBI radio observations of this unique object which contains a precessing, relativistic jet.

Dr. Jeffrey McClintock and Dr. Larry Petro completed a scanning-slit photometer which they used on four occasions at the McGraw-Hill Observatory to search for orbital periods among the faint counterparts of galactic X-ray sources. In May 1981, they used the instrument at the Cerro Tololo Interamerican Observatory in Chile and discovered a 4.3 hour period for the X-ray burst source 4U1735-44.

Dr. George Ricker, Mr. Daniel Dewey, Dr. Steven Meyer, and Dr. Marc Bautz have built and used a state-of-the-art CCD imager and spectrophotometer with high throughput and large dynamic range. The instrument was used to optically identify faint, high-latitude X-ray sources. It is scheduled for extended use this fall at Cerro Tololo Interamerican Observatory and the McGraw-Hill Observatory.

Professor Edward Wright and Dr. Charles Lawrence have used the CCD imager system mentioned above to search for the optical counterparts of radio sources discovered in the MIT 5 GHz survey.
VLA radio observations of these sources are now under way and should provide arc second positions for more than 300 of them.

During the past year, more than 20 graduate and undergraduate students have been involved directly or indirectly in the research activities of the Observatory.

JEFFREY E. MCCLINTOCK

George R. Wallace Jr. Astrophysical Observatory

The George R. Wallace 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.

The highlight of the past year's research program was the successful testing of a new CCD camera and spectrograph (MASCOT), which was designed and built by Drs. George Ricker, Mark Bautz, Steve Meyer, and their co-workers. MASCOT employs a 328 x 490 element CCD detector array that greatly increases the efficiency of our 24-inch telescope. Dr. Ricker's group was able to detect 17th magnitude stars using integration times of only a few minutes, and observed the faint outer reaches of the Crab nebula. This instrument promises to increase greatly the number of research projects that will be possible at the Observatory.

Our ongoing program to determine stellar masses and the distances to binary systems through observations of lunar occultations continued. During the past year, Professor Deane M. Peterson (State University of New York at Stony Brook) in collaboration with Dr. Edward Dunham, Richard Baron, and Douglas Mink of the Observatory staff successfully observed another series of Hyades occultations. They obtained a high-precision diameter for the brighter component of 01 Tau and resolved the binary systems 01 Tau, 02 Tau, 0342 and 71 Tau.

Several improvements were made to the Observatory facilities. Heidi Hammel, Class of 1982, rebuilt an improved design of a photoelectric photometer and Greg Aldering, Class of 1983, finished construction of new photographic equipment, both under the supervision of Mr. Baron.

During IAP, members of the MIT community attended the Observatory's open night. Also several students participated in an astrophotography program led by Dr. Dunham, and an occultation program led by Mr. Mink and Mr. Baron.

The student projects for Professor James Elliot's course in observational astronomy (12.117J-8.287J) included photoelectric photometry of FG Sge and the short-period Cepheid variable, CY Agr. Students from Professor William Pinson's astronomy classes (12.111, 12.112, 12.113, 12.114) visited the Observatory on several occasions during the fall and spring terms. Senior theses for the Department of Physics, based on work at the Observatory, were completed by Giles Novak and Michael Menzel, Class of 1981, under the supervision of Dr. Dunham and Professor Elliot.

JAMES L. ELLIOT
Vice President and Dean of the Graduate School

Annual reports for the Registrar, for the Division of Comparative Medicine, and for the Medical Department -- including the Environmental Medical Service and the Radioactivity Center -- follow the reports on the Graduate School which my associates in the Graduate Office and I have prepared.

DEAN OF THE GRADUATE SCHOOL

Tables of statistical information for the Graduate School appear at the end of this report. To facilitate ready comparison of this information for academic year 1980-81, with that for the past years, the formats of most of the tables are identical to those published in the past.

Inspection of these data show a continuation of the patterns of growth of enrollments which have been evident in recent years and a significant softening in the financial support programs available to our graduate students. In addition, the worrisome downward trends in doctor's degrees in engineering and upward trends in fractions of those degrees being awarded to foreign students have continued.

Enrollments increased in all Schools except for the School of Humanities and Social Science, in which enrollment held essentially steady (Table I). The total enrollment increase of over 5 percent from fall 1979 to fall 1980 -- to an all-time high of 4,384 -- brought the graduate population very close to that of the undergraduate body.

Considerable concern was expressed at the potential impact of continuing the current policy of graduate admissions under which each department is quite free to establish the size of its graduate admissions. Thus, at this writing, we are engaged in a careful study of the patterns of admission, enrollment, financial support, and the awarding of graduate degrees over the past decade. We hope to be able to make our results available during the fall term 1981 to forward discussions of possible policy changes governing our graduate programs.

The "softening" of financial support is evident from the information in Tables II, III, and IV, particularly when these data are compared to the equivalent data for the recent past. For example, the percentage of total enrollment of graduates who received fellowship support dropped from 13 percent to 11.5 percent from 1979 to 1980, and the percentage who were supported by graduate assistantships dropped from 50 percent to 44 percent during the same period. The percentage who received "full awards" (Table III) dropped from 70 percent to 71 percent. When viewed as an extension of the patterns of the last decade or so (Table IV), these statistics are anything but encouraging.

Like those staff who have responsibility for the Institute's undergraduate financial aid program, we are also very concerned about the potential for further weakening of graduate financial support which is forecast in the current Federal budget debates. Accordingly, we are actively seeking the reinstatement of such important "symbolic" programs as the National Science Foundation Fellowships and the Graduate Professional Opportunities Program (GPOP) under Title IX of the Higher Education Acts. In addition, we are seeking to continue the College Work Study Program (CWSF) and the need-based, interest-subsidized portion of the Guaranteed Student Loan Program.

Since we have traditionally provided support for about one-third of our total enrollment in the form of research assistantships on sponsored research programs, we are also very mindful of the uncertainties concerning the future of Federally sponsored unclassified research in universities -- evident in the ongoing debates on the Federal budget.
Finally, the increasing pressures from international students to gain admission to those programs which are most in demand by American students (e.g., engineering) must be addressed. In this arena, MIT plays a very visible and important national role. Of all of the "prestige" research universities, we have traditionally enrolled the largest fraction of graduate students. Hence, our own actions may have a significant influence on the practices of other American educational institutions which are similarly facing enormous increases in foreign applicants.

During 1980-81, the Committee on Graduate School Policy (CGSP) continued to exercise all-Institute faculty overview of our many and diverse departmental graduate programs. During the year, the CGSP either acted with power or recommended to the faculty for approval the following matters:

1) The establishment of a new interdepartmental program and degree, S.M. in Management of Technology, sponsored jointly by the Sloan School and most of the departments in the School of Engineering.

2) The establishment of a new program -- the Industrial Master's Program -- within the Master's degree programs in the Department of Electrical Engineering and Computer Science.

3) The discontinuation of the Interdisciplinary Science Master's Degree Program (Course XXV) following a six-year experiment.

4) The adoption of a new set of guidelines and procedures governing appointments of graduate students to the graduate student staff.

5) The adoption of a new letter grade "U" to identify unsatisfactory progress during any given term by a student pursuing a graduate thesis.

6) The adoption of major revisions in the Rules and Regulations of the Faculty concerning the roles of faculty committees relative to graduate educational matters.

In addition to the tri-annual evaluations of graduate students' academic performance and degree candidacies, the Committee also continued to grope -- unsuccessfully -- with clarification of criteria governing graduate and graduate A subjects of instruction; heard and lent strong support to recommendations developed by the CGSP Subcommittee on Academic Due Process; and served as a constructively critical forum for many other faculty and faculty-administrative matters impacting on graduate education.

The Graduate Student Council continued to place great emphasis on the impact of high inflation rates and tuition increases on graduate students. Although several meetings among students, faculty, and administrative staff were held to address these matters, I regret to say that no solution emerged other than "find more financing for graduate support." Those of us on the staff will, of course, continue our efforts to do precisely that -- but in a climate which is not exactly promising.

Despite this relatively gloomy outlook, I must close on a positive note. We are, after all, part of an institution of international reputation, well-respected for its vitality, flexibility, and for the quality and productivity of its faculty and student body. To maintain and, indeed, further enhance these characteristics in the near term will be a stimulating and challenging experience for all of us who are part of the fabric of the place.

KENNETH R. WADLEY

GRADUATE WOMEN

As Dean Wadleigh reported, MIT's graduate enrollment has more than held its own with regard to national trends for 1980-81. Of special interest, however, is that some of the disappointing decreases reported in last year's statistics concerning graduate women have been reversed. Once again MIT is making modest but steady progress in attracting more women to its graduate programs.
According to the annual Council of Graduate Schools/Graduate Record Examination Survey of Graduate School Enrollment, the total graduate enrollment in the fall 1980 in private Ph.D. universities decreased 1.1 percent from the previous year. In comparison to this, MIT's total graduate enrollment increased by over 5 percent (Table I). National figures also show that women represent an increasing percentage of enrollments in graduate school as well. Although the percentage of women enrolled at MIT in the fall of 1980 (18 percent) (Tables VII and VIII) does not approach the 46 percent total female enrollment in Ph.D. universities nationally, this fact is not surprising. The national figures include large liberal arts graduate schools where women traditionally have tended to enroll in larger numbers than in science and engineering programs. However, breaking down MIT's enrollment by School we find that the 10 percent enrollment of women in the School of Engineering is well in line with the 9 percent national figure. Overall the percentages of total population who are women have not changed significantly at MIT from 1979 to 1980, although MIT's total graduate women population of 779 is an all-time high and is three times the number of women enrolled 10 years ago (260 in fall of 1971).

On another positive note, the number of entering women graduate students increased over 30 percent -- from 193 in the fall of 1979 to 254 in the fall of 1980, reversing the troublesome 11 percent decrease shown last year (Table VII).

It is also important to point out that the total applicant pool has increased almost 16 percent from 1979 when no significant increase (and some decrease) was reported (see Tables VIII and IX). Particularly disappointing last year was the decrease in women applicants (-8 percent from the previous year). This has been reversed in the fall of 1980 when an increase of almost 18 percent in applications from women is indicated. Most notable is a 55 percent increase in the number of women applicants to the School of Engineering. Despite this, the total enrollment of women in engineering only increased from 8 percent to 10 percent, or an increase of 45 women. This is explained by the fact that almost half (47 percent) of MIT's total enrollment is in Engineering while only 27 percent of the women at MIT enroll in engineering programs. Therefore a slight increase in the number of men applying and admitted more than offset the large increase in women applicants.

Another significant increase in women applicants is shown in the School of Management. However, this 41 percent increase in women applicants is offset by a 38 percent increase in male applicants. Therefore the percentage of women enrolled only increased from 20 percent to 22 percent, or by a total of 14 women.

Degrees Awarded

The National Center for Educational Statistics reports that nationally women received 49.1 percent of the Master's degrees, 28.1 percent of the Doctorates, and 23.6 percent of the first professional degrees. Comparing these statistics with those for MIT which are shown in Table X, we find that the 252 women earned almost 17 percent of the total advanced degrees awarded by MIT. This statistic is another all-time MIT "high" and includes 184 women awarded Master's degrees (18 percent) and 68 (16 percent) awarded Doctorates. Data of Table XI also indicates that an equal number of more advanced degrees were awarded to women in each School (except Science) than in any of the previous 10 years. Of particular note are the 14 Doctorates earned by women in engineering departments -- double the number awarded in any previous year, when sometimes only one or two women earned such degrees.

Financial Support

The financial support picture for graduate students has not improved during the past year. Tuition and living costs continue to escalate while fewer fellowship programs are available.

The situation for women graduate students continues to be disproportionately affected since the largest proportion of women still tend to enroll in those programs at MIT whose financial resources are most limited. The outlook for the future is depressing since the resources available to such individuals through Federal loan programs may decrease due to new Federal regulations which will not only decrease the funds available but also increase the interest rates and change the eligibility requirements.
In most MIT departments, women must compete with male graduate students for research and fellowship funds. However, the Graduate School Office has available the Ida M. Green Fellowships for women entering graduate programs at MIT. In our eighth annual competition, seven women were selected for these awards, bringing the total to over 50 women supported by these funds since its inception in 1974. In addition, about six women have been designated Honorary Ida M. Green Fellows. Although these women won financial support from other national fellowship competitions, their credentials for graduate school were so outstanding that it was felt that they should be so honored. In the only other fellowship program endowed by MIT for women graduate students, one continuing graduate woman was supported by a Collamore-Rogers Fellowship (unfortunately the funds in these accounts have been depleted; this fellowship will not be awarded in the 1981-82 year). A cross section of MIT's departments is represented by these women scholars and such funds are important in attracting and increasing the number of qualified women graduate students at MIT.

As in recent years, graduate women have been recipients of awards from the IBM Corporation and Xerox Special Opportunity Fellowship Program for Minorities and Women pursuing graduate study in specific areas of interest to these companies. Two women held IBM awards and two women (one minority) received support from the Xerox program. Women enrolled in MIT graduate programs also received fellowships in national competitions from the American Association of University Women, the National Science Foundation (NSF), the Hertz Foundation, the National Institute of Mental Health, and the Danforth Foundation. Other industrial sponsors of women at MIT include Bell Laboratories and Hughes Aircraft.

Industrial fellowships are becoming an increasingly important source of financial support for graduate students in general, and we are happy to find that women are competing successfully for such support.

Although the statistics seem to imply a "success story" for women in graduate education (both nationally and at MIT) such an optimistic interpretation might not be totally justified. Women graduate students, although not consciously discriminated against, still experience some neglect as far as their treatment in traditionally male-dominated fields of study. An internal report by an ad hoc group of women faculty, staff, and students entitled "A Study of the Academic Environment for Graduate Students at MIT" deals with problems common to all graduate students but includes a section on issues of concern to women graduate students in particular. These include the need for more women faculty as mentors and role models; acceptance of women as professional colleagues; and assessing women on their professional capabilities, particularly in awarding research assistantships, scholarships, and fellowships and in recommending them for positions after completion of their graduate degree programs.

Employment opportunities certainly are not lacking as far as women in science and engineering are concerned. Thus, one of our main concerns continues to be that of enticing women to complete graduate degrees rather than to be lured away by lucrative salary offers in business and industry.

JEANNE E. RICHARD

MINORITY GRADUATE STUDENTS

I am pleased to report that minority graduate student enrollment at the Institute also took a dramatic upswing this past fall term. Minority graduate student enrollment increased 19 percent over the fall term enrollment of 1979, moving from 144 to 171. This increase was a pleasant reversal of a downward trend we had experienced for the previous three years.

Minority enrollment over the previous year increased in all of the academic Schools except the School of Science; in which there was a decrease of 26 percent. The School of Architecture and Planning led all Schools with 14.6 percent of their enrollment being minority graduate students, nearly one-third of the total minority graduate student enrollment at MIT. The School of Engineering (2.8 percent) and the School of Science (2.3 percent) continue to have a very small percentage of their total graduate enrollment as minority students.

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It appears that our total minority graduate student enrollment is driven by only one School at MIT, the School of Architecture and Planning. If that faculty has a good year recruiting, then MIT has a high minority graduate student enrollment figure. If they had a bad year, then, correspondingly, the total minority numbers fall.

A more desirable situation would be for the School of Engineering and the School of Science to be the driving forces for minority graduate student presence at the Institute simply because those two large Schools are the driving forces for the total graduate school enrollment. As long as we have only 2 percent or 3 percent of the total graduate enrollment as minority students in these two Schools, minority presence at the Institute will continue to be very, very small. Despite the minority graduate student enrollment increase of 19 percent over the previous year, minority enrollment is still just 3.9 percent of the total graduate student enrollment (see Table XII).

Efforts to recruit new minority graduate students must focus on the two larger Schools of the Institute and it must be done on a large scale if we are to ever reach satisfactory levels of minority graduate student presence at the Institute.

The Graduate School Office sponsored a number of activities during the year to attract, retain, and graduate more minority students than ever before:

- Recruitment trips to 21 colleges and universities
- Graduate Information Day Conference at New York University (This event was co-sponsored along with seven Ivy League graduate schools.)
- Minority Graduate Student Orientation Program
- Reception for black faculty and staff to meet minority graduate students
- Ebony Affair semi-formal dance for the entire MIT minority community (350 persons attended the event)
- Minority Graduate Students Lecture Series
- Reception for Dr. John Slaughter, Director of NSF
- Minority Awards Day Program
- Talbot House retreat
- Commencement reception for minority graduates and their families
- Welcoming dinner for Lincoln Laboratory Summer Program for Black Engineers and Scientists
- Graduate Information Conferences on Minorities seeking Ph.D.s in Washington, DC; Albuquerque, New Mexico; New Orleans; and Berkeley
- Presentation of papers by minority graduate students at professional meetings

JOHN B. TURNER
For simple comparison with data for 1979-80, the following statistical information for 1980-81 is presented in the same format. Numbers in parentheses indicate the change from 1979-80 to 1980-81.

### TABLE I

**REGULAR GRADUATE STUDENT ENROLLMENT, FALL TERM 1980**

<table>
<thead>
<tr>
<th>School of Architecture and Planning</th>
<th>Foreign (1)</th>
<th>Women (2)</th>
<th>Minority (3)</th>
<th>Total</th>
<th>Non-Residents (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>School of Architecture and Planning</td>
<td>96(+8)</td>
<td>133(+20)</td>
<td>61(+14)</td>
<td>390(+47)</td>
<td>28(+27)</td>
</tr>
<tr>
<td>School of Engineering</td>
<td>729(+44)</td>
<td>213(+45)</td>
<td>54(+10)</td>
<td>2088(+110)</td>
<td>4(+2)</td>
</tr>
<tr>
<td>School of Humanities and Social Science</td>
<td>87(-14)</td>
<td>91(-9)</td>
<td>17(0)</td>
<td>353(-5)</td>
<td>51(+6)</td>
</tr>
<tr>
<td>Sloan School of Management</td>
<td>101(0)</td>
<td>90(+14)</td>
<td>14(+5)</td>
<td>419(+28)</td>
<td>5(+4)</td>
</tr>
<tr>
<td>School of Science</td>
<td>266(+25)</td>
<td>231(+25)</td>
<td>28(-5)</td>
<td>1122(+55)</td>
<td>8(+2)</td>
</tr>
<tr>
<td>Health Sciences and Technology</td>
<td>4(+1)</td>
<td>1(0)</td>
<td>0</td>
<td>12(+3)</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>1283(+64)</td>
<td>779(+95)</td>
<td>174(+24)</td>
<td>4384(+238)</td>
<td>96(+41)</td>
</tr>
</tbody>
</table>

(1) Includes Canadians  
(2) See also Table IX  
(3) Includes Black Americans, Puerto Ricans, Mexican Americans, and American Indians  
(4) Included in totals

### TABLE II

**GRADUATE DEGREES AWARDED, 1980-81**

<table>
<thead>
<tr>
<th>Advanced Degrees Conferred</th>
<th>M.C.P.</th>
<th>M. Arch., M. Arch. A.S.</th>
<th>S.M.</th>
<th>Engineer</th>
<th>Sc.D.</th>
<th>Ph.D.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 1980 Woods Hole</td>
<td>19(-1)</td>
<td>163(-11)</td>
<td>6(-9)</td>
<td>0(-1)</td>
<td>12(+1)</td>
<td>84(-15)</td>
<td>4(+4)</td>
</tr>
<tr>
<td>February 1981 Woods Hole</td>
<td>11(-3)</td>
<td>221(-20)</td>
<td>25(+8)</td>
<td>0(-1)</td>
<td>17(-6)</td>
<td>115(+16)</td>
<td>5(-5)</td>
</tr>
<tr>
<td>June 1981 Woods Hole</td>
<td>52(-4)</td>
<td>547(+65)</td>
<td>40(-4)</td>
<td>1(+1)</td>
<td>17(-1)</td>
<td>141(+18)</td>
<td>0(-4)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>82(-8)</td>
<td>931(+34)</td>
<td>72(-6)</td>
<td>47(-6)</td>
<td>349(+14)</td>
<td>1481(+28)</td>
<td></td>
</tr>
</tbody>
</table>

Numbers in parentheses indicate change from 1979-80.
### 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 1980. Total regular graduate student enrollment, not including non-residents, was 4,288.

<table>
<thead>
<tr>
<th>Numbers of Students</th>
<th>Percent Total Enrollment</th>
<th>Change from 79-80</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIH and NIMH Traineeships</td>
<td>113</td>
<td>- 8</td>
</tr>
<tr>
<td>NSF National Needs Traineeships</td>
<td>0</td>
<td>- 4</td>
</tr>
<tr>
<td>DOE Fellowships</td>
<td>6</td>
<td>+ 6</td>
</tr>
<tr>
<td>HUD Minority Intern Program</td>
<td>0</td>
<td>- 5</td>
</tr>
<tr>
<td>HEW Domestic Mining and Mineral Fuel Traineeships</td>
<td>13</td>
<td>+ 4</td>
</tr>
<tr>
<td>HEW Graduate and Professional Opportunities Program Fellowships</td>
<td>14</td>
<td>- 4</td>
</tr>
<tr>
<td>HEW Public Service Education Traineeships</td>
<td>0</td>
<td>- 10</td>
</tr>
<tr>
<td>MIT Endowed and Other Fund Fellowships</td>
<td>206</td>
<td>0</td>
</tr>
<tr>
<td>Industrial and Foundation Fellowships</td>
<td>139</td>
<td>- 20</td>
</tr>
<tr>
<td><strong>491</strong></td>
<td><strong>11.5%</strong></td>
<td><strong>- 41</strong></td>
</tr>
</tbody>
</table>

**FELLOWSHIPS AWARDED BY SPONSORS TO MIT STUDENTS**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NSF Graduate Fellowships</td>
<td>144</td>
</tr>
<tr>
<td>NIMH Fellowships</td>
<td>2</td>
</tr>
<tr>
<td>Hertz Fellowships</td>
<td>41</td>
</tr>
<tr>
<td><strong>187</strong></td>
<td><strong>4%</strong></td>
</tr>
</tbody>
</table>

**STUDENT ASSISTANTSHIPS**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Assistants</td>
<td>1449</td>
</tr>
<tr>
<td>Teaching Assistants</td>
<td>419</td>
</tr>
<tr>
<td>Instructor-G</td>
<td>16</td>
</tr>
<tr>
<td><strong>1884</strong></td>
<td><strong>44%</strong></td>
</tr>
</tbody>
</table>

**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:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>US Army, Air Force, Coast Guard</td>
<td>33</td>
</tr>
<tr>
<td>US Navy and Related Programs</td>
<td>42</td>
</tr>
<tr>
<td>Foreign Countries and International Programs</td>
<td>273</td>
</tr>
<tr>
<td>Industry and Foundation (US)</td>
<td>123</td>
</tr>
<tr>
<td><strong>471</strong></td>
<td><strong>11%</strong></td>
</tr>
</tbody>
</table>

**SUMMARY BY SOURCES - FULL AWARDS**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Fellowships and Traineeships</td>
<td>292</td>
</tr>
<tr>
<td>Graduate Student Staff</td>
<td>1884</td>
</tr>
<tr>
<td>Industrial and Foundation Awards</td>
<td>180</td>
</tr>
<tr>
<td>MIT Endowed and Budgeted Funds</td>
<td>206</td>
</tr>
<tr>
<td>Students Sponsored by External Sources</td>
<td>471</td>
</tr>
<tr>
<td><strong>3033</strong></td>
<td><strong>71%</strong></td>
</tr>
</tbody>
</table>
Vice President and Dean of the Graduate School

**TABLE IV**

**TRENDS IN GRADUATE STUDENT SUPPORT**

<table>
<thead>
<tr>
<th>Years</th>
<th>Fellowships</th>
<th>Traineeships</th>
<th>Scholarships*</th>
<th>Stipend (TA)</th>
<th>Staff Salaries (RA &amp; TA)</th>
<th>MIT Only</th>
<th>Including</th>
<th>Outside</th>
<th>Agencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968-69</td>
<td>4,994 (.710)</td>
<td>1,033 (.147)</td>
<td>6,015 (.855)</td>
<td>646 (.082)</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>1969-70</td>
<td>5,197 (.712)</td>
<td>1,036 (.145)</td>
<td>6,815 (.934)</td>
<td>470 (.064)</td>
<td>643 (.088)</td>
<td>672 (.082)</td>
<td>na</td>
<td>827 (.096)</td>
<td></td>
</tr>
<tr>
<td>1970-71</td>
<td>5,396 (.655)</td>
<td>1,182 (.143)</td>
<td>6,850 (.831)</td>
<td>483 (.059)</td>
<td>672 (.082)</td>
<td>754 (.078)</td>
<td>916 (.095)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1971-72</td>
<td>5,076 (.589)</td>
<td>1,294 (.150)</td>
<td>7,086 (.823)</td>
<td>696 (.080)</td>
<td>754 (.078)</td>
<td>916 (.095)</td>
<td>201 (.101)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1972-73</td>
<td>4,687 (.486)</td>
<td>1,432 (.150)</td>
<td>7,991 (.828)</td>
<td>754 (.078)</td>
<td>916 (.095)</td>
<td>201 (.101)</td>
<td>646 (.082)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1973-74</td>
<td>3,930 (.378)</td>
<td>1,453 (.140)</td>
<td>8,781 (.844)</td>
<td>852 (.082)</td>
<td>1,014 (.097)</td>
<td>754 (.078)</td>
<td>201 (.101)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1974-75</td>
<td>3,969 (.318)</td>
<td>1,738 (.150)</td>
<td>9,760 (.840)</td>
<td>1,075 (.093)</td>
<td>1,293 (.111)</td>
<td>646 (.082)</td>
<td>201 (.101)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1975-76</td>
<td>3,447 (.259)</td>
<td>1,878 (.141)</td>
<td>10,878 (.816)</td>
<td>1,141 (.086)</td>
<td>1,407 (.106)</td>
<td>646 (.082)</td>
<td>201 (.101)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1976-77</td>
<td>3,454 (.229)</td>
<td>2,065 (.137)</td>
<td>11,654 (.772)</td>
<td>1,419 (.094)</td>
<td>2,013 (.133)</td>
<td>646 (.082)</td>
<td>201 (.101)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1977-78</td>
<td>3,418 (.205)</td>
<td>1,978 (.118)</td>
<td>12,479 (.750)</td>
<td>1,391 (.084)</td>
<td>2,201 (.132)</td>
<td>646 (.082)</td>
<td>201 (.101)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1978-79</td>
<td>3,667 (.198)</td>
<td>2,355 (.127)</td>
<td>15,251 (.823)</td>
<td>962 (.052)</td>
<td>2,387 (.129)</td>
<td>646 (.082)</td>
<td>201 (.101)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1979-80</td>
<td>3,733 (.172)</td>
<td>3,079 (.142)</td>
<td>16,610 (.766)</td>
<td>976 (.045)</td>
<td>3,575 (.165)</td>
<td>646 (.082)</td>
<td>201 (.101)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980-81</td>
<td>3,388 (.127)</td>
<td>2,821 (.106)</td>
<td>18,650 (.702)</td>
<td>434 (.016)</td>
<td>4,434 (.167)</td>
<td>646 (.082)</td>
<td>201 (.101)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Administered by the Graduate School Office

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).

**TABLE V**

**DISTRIBUTION OF FUNDING FOR GRADUATE STUDENT TUITION AND LIVING EXPENSES**

**FALL TERM 1980**

Estimates of Required Funding

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuition</td>
<td>$13,064,797</td>
<td></td>
</tr>
<tr>
<td>Stipend ($570/mo. for 4-1/2 months)</td>
<td>10,981,905</td>
<td></td>
</tr>
<tr>
<td>Total Estimated Required Funding</td>
<td>$24,046,702</td>
<td></td>
</tr>
</tbody>
</table>

Identified Support by Category

<table>
<thead>
<tr>
<th>Category</th>
<th>Amount</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Assistantships</td>
<td>$8,093,540</td>
<td>(33.5%)</td>
</tr>
<tr>
<td>Teaching Assistantships and Inst. G.</td>
<td>2,791,256</td>
<td>(11.8%)</td>
</tr>
<tr>
<td>Federal Fellowships and Traineeships</td>
<td>1,537,372</td>
<td>(6.3%)</td>
</tr>
<tr>
<td>General and Endowed Support (Departmentally controlled)</td>
<td>840,303</td>
<td>(3.3%)</td>
</tr>
<tr>
<td>General and Endowed Support (Graduate School Office controlled)</td>
<td>472,365</td>
<td>(1.9%)</td>
</tr>
<tr>
<td>Outside Sources Administered by Departments</td>
<td>726,179</td>
<td>(3.0%)</td>
</tr>
<tr>
<td>Outside Sources Administered by Graduate School Office</td>
<td>419,466</td>
<td>(1.9%)</td>
</tr>
<tr>
<td>Outside Sources, Direct Billing to Sponsor by Institute,</td>
<td>1,127,187</td>
<td>(4.5%)</td>
</tr>
<tr>
<td>Total Identified Support</td>
<td>$16,007,670</td>
<td>(66.3%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loans</td>
<td>1,985,123</td>
<td>(8.0%)</td>
</tr>
<tr>
<td>College Work-Study</td>
<td>459,992</td>
<td>(1.9%)</td>
</tr>
</tbody>
</table>

304
### TABLE VI

**DOCTORAL DEGREES AWARDED EACH YEAR BY SCHOOL AND CITIZENSHIP**

Each number is the total of the degrees awarded in September, February, and June of the academic year indicated. The numbers in parentheses are the number of degrees awarded divided by the corresponding enrollment.

<table>
<thead>
<tr>
<th>Academic Year</th>
<th>Arch.</th>
<th>Eng'g.</th>
<th>Hum. &amp; Soc. Sci.</th>
<th>Sloan</th>
<th>Science</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-71</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citizen</td>
<td>2 (.011)</td>
<td>116 (.108)</td>
<td>30 (.152)</td>
<td>10 (.043)</td>
<td>144 (.190)</td>
<td>302 (.124)</td>
</tr>
<tr>
<td>Foreign</td>
<td>1 (.026)</td>
<td>59 (.123)</td>
<td>7 (.125)</td>
<td>2 (.022)</td>
<td>29 (.134)</td>
<td>98 (.114)</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>175</td>
<td>37</td>
<td>12</td>
<td>173</td>
<td>400</td>
</tr>
<tr>
<td>1971-72</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citizen</td>
<td>5 (.028)</td>
<td>102 (.095)</td>
<td>36 (.191)</td>
<td>4 (.019)</td>
<td>149 (.212)</td>
<td>296 (.126)</td>
</tr>
<tr>
<td>Foreign</td>
<td>1 (.020)</td>
<td>60 (.123)</td>
<td>9 (.143)</td>
<td>3 (.030)</td>
<td>49 (.249)</td>
<td>122 (.136)</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>162</td>
<td>45</td>
<td>17</td>
<td>198</td>
<td>418</td>
</tr>
<tr>
<td>1972-73</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citizen</td>
<td>4 (.022)</td>
<td>112 (.107)</td>
<td>34 (.160)</td>
<td>4 (.017)</td>
<td>122 (.169)</td>
<td>276 (.115)</td>
</tr>
<tr>
<td>Foreign</td>
<td>1 (.020)</td>
<td>54 (.114)</td>
<td>17 (.274)</td>
<td>3 (.024)</td>
<td>45 (.208)</td>
<td>120 (.129)</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>166</td>
<td>51</td>
<td>7</td>
<td>173</td>
<td>396</td>
</tr>
<tr>
<td>1973-74</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citizen</td>
<td>6 (.034)</td>
<td>93 (.088)</td>
<td>29 (.136)</td>
<td>5 (.021)</td>
<td>129 (.179)</td>
<td>262 (.109)</td>
</tr>
<tr>
<td>Foreign</td>
<td>1 (.016)</td>
<td>49 (.099)</td>
<td>18 (.273)</td>
<td>6 (.052)</td>
<td>42 (.196)</td>
<td>116 (.122)</td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>142</td>
<td>47</td>
<td>11</td>
<td>173</td>
<td>378</td>
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<tr>
<td>1974-75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Citizen</td>
<td>7 (.037)</td>
<td>104 (.095)</td>
<td>31 (.143)</td>
<td>10 (.040)</td>
<td>110 (.146)</td>
<td>262 (.105)</td>
</tr>
<tr>
<td>Foreign</td>
<td>2 (.033)</td>
<td>56 (.107)</td>
<td>10 (.154)</td>
<td>8 (.089)</td>
<td>24 (.119)</td>
<td>100 (.103)</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>160</td>
<td>41</td>
<td>18</td>
<td>178</td>
<td>382</td>
</tr>
<tr>
<td>1975-76</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citizen</td>
<td>1 (.005)</td>
<td>83 (.073)</td>
<td>49 (.232)</td>
<td>12 (.055)</td>
<td>126 (.162)</td>
<td>271 (.106)</td>
</tr>
<tr>
<td>Foreign</td>
<td>1 (.019)</td>
<td>67 (.114)</td>
<td>7 (.119)</td>
<td>2 (.017)</td>
<td>42 (.180)</td>
<td>119 (.113)</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>150</td>
<td>56</td>
<td>14</td>
<td>168</td>
<td>390</td>
</tr>
<tr>
<td>1976-77</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Citizen</td>
<td>6 (.026)</td>
<td>79 (.068)</td>
<td>33 (.155)</td>
<td>2 (.007)</td>
<td>125 (.156)</td>
<td>245 (.090)</td>
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<tr>
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<td>4 (.071)</td>
<td>64 (.106)</td>
<td>19 (.264)</td>
<td>1 (.010)</td>
<td>46 (.199)</td>
<td>134 (.126)</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>143</td>
<td>52</td>
<td>3</td>
<td>171</td>
<td>379</td>
</tr>
<tr>
<td>1977-78</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Citizen</td>
<td>5 (.023)</td>
<td>111 (.096)</td>
<td>50 (.240)</td>
<td>8 (.029)</td>
<td>119 (.146)</td>
<td>293 (.110)</td>
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<tr>
<td>Foreign</td>
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<td>66 (.103)</td>
<td>13 (.169)</td>
<td>12 (.139)</td>
<td>35 (.141)</td>
<td>132 (.115)</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>177</td>
<td>63</td>
<td>25</td>
<td>154</td>
<td>425</td>
</tr>
<tr>
<td>1978-79</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Citizen</td>
<td>10 (.041)</td>
<td>80 (.066)</td>
<td>35 (.164)</td>
<td>10 (.035)</td>
<td>126 (.151)</td>
<td>261 (.093)</td>
</tr>
<tr>
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<td>64 (.101)</td>
<td>11 (.130)</td>
<td>9 (.088)</td>
<td>33 (.142)</td>
<td>120 (.105)</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>144</td>
<td>46</td>
<td>19</td>
<td>159</td>
<td>381</td>
</tr>
<tr>
<td>1979-80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citizen</td>
<td>8 (.031)</td>
<td>96 (.074)</td>
<td>40 (.156)</td>
<td>5 (.017)</td>
<td>127 (.153)</td>
<td>276 (.094)</td>
</tr>
<tr>
<td>Foreign</td>
<td>3 (.034)</td>
<td>66 (.096)</td>
<td>11 (.109)</td>
<td>3 (.029)</td>
<td>28 (.115)</td>
<td>111 (.091)</td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>162</td>
<td>51</td>
<td>8</td>
<td>155</td>
<td>387</td>
</tr>
<tr>
<td>1980-81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citizen</td>
<td>12 (.044)</td>
<td>88 (.065)</td>
<td>40 (.178)</td>
<td>7 (.022)</td>
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<td>265 (.088)</td>
</tr>
<tr>
<td>Foreign</td>
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<td>75 (.103)</td>
<td>12 (.153)</td>
<td>2 (.020)</td>
<td>35 (.130)</td>
<td>131 (.104)</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>163</td>
<td>52</td>
<td>9</td>
<td>153</td>
<td>396</td>
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</tbody>
</table>
## TABLE VII
WOMEN GRADUATE STUDENT ENROLLMENT
(\% of Total 1973-1980)

<table>
<thead>
<tr>
<th>Fall Term</th>
<th>New Women</th>
<th>Total</th>
<th>% of Women</th>
<th>Continuing Women</th>
<th>Total</th>
<th>% of Women</th>
<th>Total</th>
<th>% of Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>105</td>
<td>1080</td>
<td>10%</td>
<td>213</td>
<td>2278</td>
<td>9%</td>
<td>318</td>
<td>3358</td>
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<tr>
<td>1974</td>
<td>140</td>
<td>1061</td>
<td>13%</td>
<td>265</td>
<td>2407</td>
<td>11%</td>
<td>405</td>
<td>3468</td>
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<tr>
<td>1975</td>
<td>175</td>
<td>1113</td>
<td>16%</td>
<td>312</td>
<td>2490</td>
<td>12.5%</td>
<td>487</td>
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<td>1976</td>
<td>185</td>
<td>1220</td>
<td>15%</td>
<td>361</td>
<td>2554</td>
<td>14%</td>
<td>546</td>
<td>3774</td>
</tr>
<tr>
<td>1977</td>
<td>192</td>
<td>1184</td>
<td>16%</td>
<td>367</td>
<td>2640</td>
<td>14%</td>
<td>559</td>
<td>3824</td>
</tr>
<tr>
<td>1978</td>
<td>218</td>
<td>1259</td>
<td>17%</td>
<td>388</td>
<td>2685</td>
<td>14%</td>
<td>606</td>
<td>3944</td>
</tr>
<tr>
<td>1979</td>
<td>193</td>
<td>1202</td>
<td>16%</td>
<td>491</td>
<td>2944</td>
<td>16.6%</td>
<td>684</td>
<td>4146</td>
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<tr>
<td>1980</td>
<td>254</td>
<td>1308</td>
<td>19%</td>
<td>525</td>
<td>3076</td>
<td>17%</td>
<td>779</td>
<td>4384</td>
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### TABLE VIII

**WOMEN GRADUATE STUDENT ENROLLMENT**

Comparison of Fall Term Enrollments - 1979 and 1980

<table>
<thead>
<tr>
<th>School of Architecture and Planning</th>
<th>Number of Women</th>
<th>% of Women in Total Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture IV</td>
<td>61 71</td>
<td>34% 35%</td>
</tr>
<tr>
<td>Urban Studies and Planning XI</td>
<td>72 82</td>
<td>45% 44%</td>
</tr>
<tr>
<td></td>
<td>133 153</td>
<td>39% 39%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>School of Engineering</th>
<th>Number of Women</th>
<th>% of Women in Total Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeronautics and Astronautics XVI</td>
<td>6 12</td>
<td>4% 7%</td>
</tr>
<tr>
<td>Chemical Engineering X</td>
<td>35 34</td>
<td>16% 17%</td>
</tr>
<tr>
<td>Civil Engineering I</td>
<td>21 37</td>
<td>8% 13%</td>
</tr>
<tr>
<td>Electrical Engineering and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Science VI, VI-A, VI-W</td>
<td>46 47</td>
<td>9% 8%</td>
</tr>
<tr>
<td>Materials Science III, III-B, III-W</td>
<td>26 33</td>
<td>15% 16%</td>
</tr>
<tr>
<td>Mechanical Engineering II, II-T, II-W</td>
<td>23 36</td>
<td>7% 10%</td>
</tr>
<tr>
<td>Nuclear Engineering XXII</td>
<td>8 10</td>
<td>2% 6%</td>
</tr>
<tr>
<td>Ocean Engineering XIII, XIII-A, XIII-B, XIII-W</td>
<td>3 4</td>
<td>5% 2.5%</td>
</tr>
<tr>
<td></td>
<td>168 213</td>
<td>8% 10%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>School of Humanities and Social Science</th>
<th>Number of Women</th>
<th>% of Women in Total Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economics XIV</td>
<td>19 17</td>
<td>15% 14%</td>
</tr>
<tr>
<td>Linguistics and Philosophy XXIV</td>
<td>27 22</td>
<td>40% 32%</td>
</tr>
<tr>
<td>Political Science XVII</td>
<td>42 40</td>
<td>33% 32%</td>
</tr>
<tr>
<td>Psychology IX</td>
<td>12 12</td>
<td>35% 34%</td>
</tr>
<tr>
<td></td>
<td>100 91</td>
<td>28% 26%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sloan School of Management</th>
<th>Number of Women</th>
<th>% of Women in Total Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management XV</td>
<td>63 75</td>
<td>20% 22%</td>
</tr>
<tr>
<td>XV-A (Fellows)</td>
<td>7 9</td>
<td>13% 16%</td>
</tr>
<tr>
<td>XV-B (Operations Research)</td>
<td>6 6</td>
<td>26% 35%</td>
</tr>
<tr>
<td></td>
<td>76 90</td>
<td>19% 21%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>School of Science</th>
<th>Number of Women</th>
<th>% of Women in Total Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology VII</td>
<td>33 33</td>
<td>30% 26%</td>
</tr>
<tr>
<td>VII-W</td>
<td>4 7</td>
<td>21% 35%</td>
</tr>
<tr>
<td>Chemistry V</td>
<td>30 35</td>
<td>16% 17.5%</td>
</tr>
<tr>
<td>Earth and Planetary Science XII</td>
<td>11 14</td>
<td>14% 16%</td>
</tr>
<tr>
<td>XII-W</td>
<td>14 11</td>
<td>32% 34%</td>
</tr>
<tr>
<td>Mathematics XVIII</td>
<td>18 21</td>
<td>16% 18%</td>
</tr>
<tr>
<td>Meteorology and Physical Oceanography XIX</td>
<td>1 4</td>
<td>2% 9%</td>
</tr>
<tr>
<td>XIX-W</td>
<td>3 4</td>
<td>25% 31%</td>
</tr>
<tr>
<td>Nutrition and Food Science XX</td>
<td>62 64</td>
<td>35% 38%</td>
</tr>
<tr>
<td>Physics VIII</td>
<td>20 27</td>
<td>7% 9%</td>
</tr>
<tr>
<td>Interdisciplinary Science XXV</td>
<td>10 11</td>
<td>67% 61%</td>
</tr>
<tr>
<td></td>
<td>206 237</td>
<td>20.5% 19%</td>
</tr>
<tr>
<td>HST</td>
<td>1 1</td>
<td>11% 8%</td>
</tr>
<tr>
<td>TOTALS</td>
<td>684 779</td>
<td>16.5% 18%</td>
</tr>
</tbody>
</table>
TABLE IX
COMPARISON OF ADMISSIONS STATISTICS FOR GRADUATE WOMEN AND GRADUATE MEN
Number of Applicants 1979/Number of Applicants 1980

Numbers in parentheses indicate the percent change in number of applicants from 1979 to 1980

<table>
<thead>
<tr>
<th>School of Architecture and Planning</th>
<th>Women</th>
<th>309/334(+8%)</th>
<th>Men</th>
<th>605/634(+5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>School of Engineering</td>
<td>188/254(+35%)</td>
<td>2475/2716(+10%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School of Humanities and Social Science</td>
<td>136/156(+15%)</td>
<td>447/446(−.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sloan School of Management</td>
<td>303/428(+41%)</td>
<td>1183/1631(+38%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School of Science</td>
<td>353/456(+29%)</td>
<td>1237/1300(+5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1289/1628(+26.2%)</td>
<td>5947/6727(+13.1%)</td>
<td></td>
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TABLE X
COMPARISON, IN NUMBERS, OF DEGREES AWARDED TO MEN AND WOMEN
1973-74 to 1980-81

<table>
<thead>
<tr>
<th></th>
<th>Master's</th>
<th>Engineer's</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Women</td>
<td>Total</td>
<td>% of Women</td>
</tr>
<tr>
<td>1973-74</td>
<td>58</td>
<td>832</td>
<td>7%</td>
</tr>
<tr>
<td>1974-75</td>
<td>80</td>
<td>856</td>
<td>9%</td>
</tr>
<tr>
<td>1975-76</td>
<td>93</td>
<td>862</td>
<td>11%</td>
</tr>
<tr>
<td>1976-77</td>
<td>145</td>
<td>971</td>
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<tr>
<td>1977-78</td>
<td>134</td>
<td>934</td>
<td>14%</td>
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<tr>
<td>1978-79</td>
<td>145</td>
<td>968</td>
<td>15%</td>
</tr>
<tr>
<td>1979-80</td>
<td>156</td>
<td>984</td>
<td>16%</td>
</tr>
<tr>
<td>1980-81</td>
<td>184</td>
<td>1018</td>
<td>18%</td>
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* without Engineer's degrees
<table>
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<td>13</td>
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<td>34</td>
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<td>16</td>
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<td>28</td>
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<td>20</td>
<td>19</td>
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<td>28</td>
<td>25**</td>
<td>18</td>
<td>22**</td>
<td>28**</td>
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<tr>
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<tr>
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</table>

* M.Arch., M.C.P., S.M.  
** includes 2 WHOI degrees
TABLE XII
TOTAL AND MINORITY REGULAR GRADUATE ENROLLMENT

Vice President and Dean of the Graduate School

<table>
<thead>
<tr>
<th>Architecture and Planning</th>
<th>Total Graduate Students</th>
<th>Minority Graduate Students</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA</td>
<td>PR</td>
<td>MA</td>
<td>AI</td>
</tr>
<tr>
<td>Architecture</td>
<td>12(5)</td>
<td>3(2)</td>
<td>4(2)</td>
</tr>
<tr>
<td>Urban Studies and Planning</td>
<td>28(12)</td>
<td>4(1)</td>
<td>3(1)</td>
</tr>
<tr>
<td>Engineering</td>
<td>390</td>
<td>14.6%</td>
<td></td>
</tr>
<tr>
<td>Aeronautics and Astronautics</td>
<td>3(1)</td>
<td>1(1)</td>
<td>3(1)</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>2(1)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>2(1)</td>
<td>1</td>
<td>1(1)</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>18(9)</td>
<td>3(2)</td>
<td>1(1)</td>
</tr>
<tr>
<td>Materials Science and Engineering</td>
<td>37(16)</td>
<td>9(3)</td>
<td>11(5)</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>6(2)</td>
<td>1</td>
<td>6(2)</td>
</tr>
<tr>
<td>Nuclear Engineering</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Ocean Engineering</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sloan School of Management</td>
<td>16(4)</td>
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</tr>
<tr>
<td>Humanities and Social Science</td>
<td>419</td>
<td>4.2%</td>
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</tr>
<tr>
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<td>7(1)</td>
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</tr>
<tr>
<td>Science</td>
<td>353</td>
<td>4.2%</td>
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</tr>
<tr>
<td>Biology</td>
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</tr>
<tr>
<td>Chemistry</td>
<td>4(1)</td>
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<td>1</td>
</tr>
<tr>
<td>Earth and Planetary Sciences</td>
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<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Interdisciplinary Science</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mathematics</td>
<td>1(1)</td>
<td>0</td>
<td>1(1)</td>
</tr>
<tr>
<td>Meteorology and Physical Oceanography</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nutrition and Food Science</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Physics</td>
<td>16(5)</td>
<td>6(1)</td>
<td>3(1)</td>
</tr>
<tr>
<td>TOTALS</td>
<td>121(42)</td>
<td>23(7)</td>
<td>22(9)</td>
</tr>
</tbody>
</table>

1Does not include Special Graduate Students, HST Graduate Students, and Woods Hole (XII-W, XIX-W)

2BA - Black Americans PR - Puerto Ricans MA - Mexican Americans AI - American Indians

*( ) = new students
The major preoccupation this past year has been, predictably, the move to our new building. We have been worrying about a range of concerns encompassing both the physical and the functional content of the new facility. The complexity of the process may be indicated by a partial list of some of the new entities with which we will be dealing:

- Pharmacy
- Child Care Center
- X-ray fluoroscopy and contrast studies
- Record transport system
- "Clusters" and Health-care teams
- Decentralized Walk-in Service
- Appointment-making system
- Telecommunication system

In addition, we will have some new opportunities. Although we are a licensed hospital, the Medical Department has not applied for accreditation by the Joint Commission on Accreditation of Hospitals. The physical characteristics of our current Infirmary building are such that we have been unable to comply with some of the life-safety requirements. With our splendid new facility, however, this obstacle will no longer exist, and our goal is to achieve accreditation within a year after occupancy. Dr. John M. Moses, who has acquired scars and grey hairs in the past while ushering hospitals through the accreditation process, has assumed the chairmanship of our accreditation committee, and data are being gathered already.

Also important in achieving and maintaining accreditation -- as well as in the functioning of the Department -- is quality assurance. This committee, under the chairmanship of Dr. Samuel W. Stein and with the help of Rochelle Alexander, formulated a statement of its mission and a plan for its function. It thereafter completed two studies, one on waiting times and another concerned with urinary tract infections. Other studies are in process.

A major concern referred to in our last report has been the degree to which people in our community are unaware of the resources available in this Department. Last year we did succeed in finishing and distributing two publications: "Guide to Obstetrical Services" and "A Student Guide to the MIT Medical Department." A brochure describing the Health Surveillance Program has also been distributed. This latter program is currently being reassessed. We have encountered problems in keeping track of participants, so that some patients have not been reminded promptly that a "check-up" is due. We are also interested in increasing the level of participation in the program and in using it as a gateway and link to our health education and information programs.

Efforts to increase awareness of this Department in the community last year included 29 lectures given by Medical Department personnel during Independent Activities Period (IAP). Topics included smoking, weight control, birth control, sports medicine, menstrual disorders, blood sugar levels, alcohol problems, and urinary tract infections. Approximately 770 people attended. This represented a substantial accomplishment by the Health Education and Information Service, which had not only continued its ongoing programs but also initiated a stress management workshop, a series of lectures on topics regarding nutrition, and three evening programs about contraception held for students in the dormitories. Dr. Bruce J. Biller last year served as physician coordinator for some of the health education activities and was very helpful to Constance A. Bean and Iris Ponzielli Goldberg. The total number of participants in programs conducted by this service was 1,108.

For some time we have been concerned about remaining involved in the care of our patients who are admitted to hospitals under the care of non-MIT physicians. Pauline R. Jones has been actively engaged in establishing a linkage between these people and their primary physicians here with the help of a hospital liaison committee, chaired by Dr. Edward S. Rendall. Last year, we experienced an extraordinary increase in the utilization of outside hospitals by our Health Plan patients. This has required strengthening this hospital liaison activity by structuring and enhancing the mechanisms of communication between primary-care doctors here and outside physicians. Our goal is to shorten the length of our patients' stay in outside hospitals -- primarily by the appropriate use of our infirmary. With hospital care costs in the Boston area running in excess of $480 per day (excluding psychiatric hospitalization), the motivation is strong. There will be no increment of risk to any patient in this effort.
As planned, we did increase our participation in the primary-care residency training program of
the Mount Auburn Hospital. Dr. John Ingard, no stranger to MIT, spent six months here partici-
pating in ambulatory care under the preceptorship of Dr. Michael A. Kane, and with the super-
vision of members of the psychiatry, ophthalmology, gynecology, dermatology, and pediatric
staffs. Both Dr. Ingard and we were very pleased with this experience.

Level of Activity

Last year saw an apparent reversal of several recent trends. Although the total number of visits
(121,105) continued to increase, the increment was quite small (0.6 percent). Even if dental
visits are excluded, the number is up only by 1 percent. This overall change is actually made
up of decreases in almost all of the primary-care areas (Internal Medicine, Surgery, Pediatrics,
Psychiatry) with some substantial increases in several of the specialties.

Students, however, made more visits last year, and made them "across the board" to all services
except Psychiatry and the Off-hours Clinic. Leaving aside the dental service, students made
1,028 more visits to the Department, an increase of 3 percent.

The reasons for this are straightforward: increased utilization in the specialty areas represents
increased availability of physician time in those areas; the larger number of student visits
corresponds quite closely to the larger number of students.

Although the temptation to claim prescience in allocating resources is very strong, it is more
likely that the horse of increased physician time came before the cart of increase utilization.
It is hoped, nonetheless, that some favorable comments made by students about the Department
recently may be representative of general student attitudes, as suggested by the patient attitude
survey last year.

Herewith some columns for comparison:

<table>
<thead>
<tr>
<th>VISITS TO DEPARTMENT (by fiscal year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>--------------------------------------</td>
</tr>
<tr>
<td>TOTAL VISITS (Less Dental)</td>
</tr>
<tr>
<td>Total (Less Dental and Lincoln)</td>
</tr>
<tr>
<td>Internal Medicine</td>
</tr>
<tr>
<td>Surgery</td>
</tr>
<tr>
<td>Pediatrics</td>
</tr>
<tr>
<td>Nursing</td>
</tr>
<tr>
<td>Orthopedics</td>
</tr>
<tr>
<td>Ob/Gyn</td>
</tr>
<tr>
<td>Eye (Ophthalmology plus Optometry)</td>
</tr>
<tr>
<td>Social Work</td>
</tr>
<tr>
<td>STUDENT TOTAL (Less Dental)</td>
</tr>
<tr>
<td>Internal Medicine</td>
</tr>
<tr>
<td>Surgery</td>
</tr>
<tr>
<td>Nursing</td>
</tr>
<tr>
<td>Orthopedics</td>
</tr>
<tr>
<td>Ob/Gyn</td>
</tr>
<tr>
<td>HEALTH PLAN TOTAL (Less Dental)</td>
</tr>
</tbody>
</table>

Average Visits/Student: 4.3 vs. 4.0
Average Visits/Health Plan Member: >6 vs. >6
Medical Department

Staff Changes

Last year, there were comparatively few changes in personnel -- a welcome state of stability. However, some major changes did occur which do not appear on the following list. However, Dr. George Thorn ended his term as chairman of the Medical Administrative Board, the governing body of the Medical Department. Much has been said and written about Dr. Thorn; we would only add a note of profound Departmental and personal appreciation.

In noting its contributions to the City of Cambridge "in lieu of taxes" next year, the Institute might well add the name of Dr. Melvin H. Chalfen. Dr. Chalfen has left his position here as assistant medical director in charge of the Environmental Medical Service in order to serve as commissioner for health and hospitals for the City of Cambridge. Fortunately, his patients here will continue to have the benefit of his excellent medical care.

<table>
<thead>
<tr>
<th>APPOINTMENTS</th>
<th>PROMOTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rochelle Alexander</td>
<td>Richard I. Chamberlin</td>
</tr>
<tr>
<td>Quality Assurance Coordinator</td>
<td>Acting Director, Environmental</td>
</tr>
<tr>
<td></td>
<td>Medical Service</td>
</tr>
<tr>
<td>Joyce Bishop, P.A.</td>
<td>Linda Ronis-Kass</td>
</tr>
<tr>
<td>Physician Assistant</td>
<td>Audologist</td>
</tr>
<tr>
<td>(Reappointment)</td>
<td>Frederick Schaefer</td>
</tr>
<tr>
<td>Eric Chivian, M.D.</td>
<td>Assistant Biohazards</td>
</tr>
<tr>
<td>Psychiatrist</td>
<td>Assessment Officer</td>
</tr>
<tr>
<td>Laurent Delli-Bovi, M.D.</td>
<td>George Taylor, P.A.</td>
</tr>
<tr>
<td>Obstetrician/Gynecologist</td>
<td>Physician Assistant</td>
</tr>
<tr>
<td>Richard Fink</td>
<td></td>
</tr>
<tr>
<td>Assistant Biohazards Assessment Officer</td>
<td></td>
</tr>
<tr>
<td>Lois High, R.N.</td>
<td>Joyce Arlington, R.N.P.</td>
</tr>
<tr>
<td>Inpatient Nurse</td>
<td>Nurse Practitioner</td>
</tr>
<tr>
<td>Justina Leler</td>
<td>Donald Bartlett, P.A.</td>
</tr>
<tr>
<td>Supervisor, Accounting and Billing Services</td>
<td>Physician Assistant</td>
</tr>
<tr>
<td>Gioia Morongell</td>
<td>Peggy Lee Coulter, R.N.P.</td>
</tr>
<tr>
<td>Enrollment Services Manager</td>
<td>Nurse Practitioner</td>
</tr>
<tr>
<td>Humphrey Morris, M.D.</td>
<td>Shirley Hjort</td>
</tr>
<tr>
<td>Postdoctoral Fellow, Psychiatrist</td>
<td>Marketing Representative, MIT</td>
</tr>
<tr>
<td></td>
<td>Health Plan</td>
</tr>
<tr>
<td>Fe Pastorfide, D.M.D.</td>
<td>Justina Leler</td>
</tr>
<tr>
<td>Dentist</td>
<td>Supervisor, Accounting and Billing Services</td>
</tr>
<tr>
<td>Jean Prahl, R.N.P.</td>
<td>Howard Marton, M.D.</td>
</tr>
<tr>
<td>Nurse Practitioner (Reappointment)</td>
<td>Ophthalmologist</td>
</tr>
<tr>
<td></td>
<td>Elizabeth Matteson, R.N.</td>
</tr>
<tr>
<td></td>
<td>Inpatient Nurse</td>
</tr>
</tbody>
</table>

RESIGNATIONS

Joyce Arlington, R.N.P. Nurse Practitioner
Donald Bartlett, P.A. Physician Assistant
Peggy Lee Coulter, R.N.P. Nurse Practitioner
Shirley Hjort Marketing Representative, MIT Health Plan

CHANGES

Marie Jean Senior Manager, Claims and Members Services
Norma Loomis Provider/Third Party Liaison Officer

Dental Service

Changes in this area continue. Monthly staff meetings and educational sessions, revision of the Procedures Manual, initiation of a study of analgesics, and planning for a dental health education seminar for students all occurred last year. A slight decline in number of patients seen was attributable to a temporary reduction in available professional time.
Vice President and Dean of the Graduate School

Obstetrics and Gynecology

This busy service again experienced an increase in utilization (15 percent) and a dramatic rise in student visits (to 1,451) of 32 percent. Many of the student visits were with Barbara Merrifield, nurse midwife, who also presided at the delivery of 21 infants. A total of 146 deliveries occurred.

Because of increasing commitments elsewhere, Dr. Laurent Delli-Bovi is leaving us. Dr. Toni Walzer will be joining Dr. Charles F. Eades and Dr. Fruma W. Ginsburgh in mid-July as the third full-time physician on this hard-working service.

Psychiatry Service

As has become traditional, Dr. Merton A. Kahne offers the following capsule:

The plight of graduate students and their families remains the single most intractable social problem among our student population. Along with the general economic stringencies, cutbacks in research funding, housing shortages, and generally reduced social assistance programs place additional burdens on this group which undermine their educational objectives.

Utilization of the service decreased slightly. Students comprise about 40 percent of patients but make only 3 percent of total visits. The majority of patients (60 percent) are not Health Plan members, but the majority of visits (>50 percent) are made by Health Plan members.

Although the total number of referrals continued to rise, there were fewer to private practitioners and clinics. This was due in part to the steady growth of our extended psychotherapy program, now in its second year.

The number of patients hospitalized and the total number of hospital days fell. The use of the Infirmary shared in this decline.

Social Work Service

The demand for services has been steady and strong this last year. Implementation of a referral protocol for Infirmary patients has clearly met a need and seems to be working well enough to be used in other locations in the Department.

In response to the high level of need for clinical services, the Service has begun to offer more group counseling. Groups have been provided for persons with alcohol problems, single working mothers, and parents of adolescents. Further response to the increasing demand for services will be facilitated by a new statistical system implemented last year, which will create a better understanding of the clinical activities provided.

The Service participated in the Department's educational efforts during IAP on the topics of sexual abuse and alcoholism. Ronald C. Fleming, chief of the Social Work Service, submitted a series of articles on alcoholism to the MIT Health Plan Newsletter. Efforts are under way to develop a relationship with the Boston College School of Social Work, which will permit placement for graduate social work students within our Service.

The Institute Personal Assistance Program continues to enjoy wide and growing community acceptance. Approximately two-thirds of the people referred to the Program are demonstrably helped. Last year, a new series of training and orientation sessions was held for new supervisors at Draper and Lincoln laboratories. Many sessions were held on campus as well. Updating was also provided.

Environmental Medical Service

The Environmental Medical Service (EMS) has seen a series of interlocking changes in personnel which might be the envy of a soap-opera writer.
The void left by Dr. Chalfen will be filled by Richard I. Chamberlin who has agreed to be acting director of EMS while continuing as head of the Industrial Hygiene Office. Francis X. Massé has assumed the position of head of the Radiation Protection Office and is the new Institute radiation protection officer. He will continue to have major responsibility for the radiation protection program at the Bates Linear Accelerator. Murray M. Bolton, who has so ably functioned as acting Institute radiation protection officer, has, with expressions of relief, given up that task and will continue to serve as a senior member of the Radiation Protection Office. At this time, Dr. Daniel F. Liberman, head of the Biohazards Assessment Office, has been appointed visiting scientist at Tel-Aviv University in Israel. All of this denotes, obviously, a very dynamic situation.

Meanwhile, there are some welcome indications that government agencies may be persuaded to conclude that research and teaching laboratories are different from industry. We hope that guidelines rather than regulations will be recommended and that these will be based on provision of good facilities, good work practices, and good monitoring programs. The opportunity to exercise special expertise and good judgment in advising the MIT community on control of work-related health hazards is welcomed by the staff of EMS.

The disposal of hazardous laboratory wastes continues to be a major concern. The MIT Safety Office has the responsibility for collection and disposal of such material. The relationship between that department and EMS continues to be very good. However, lack of adequate disposal facilities continues to present formidable difficulties. A proper incinerating capability for disposal of hazardous waste appears to be essential.

Health Plan and Administration

The following is submitted by Laurence H. Bishoff: This year, in contrast to any previous year in the short history of the MIT Health Plan, the membership remained essentially constant. Enrollment grew less than 2 percent during the year to 7,476 members. Previous annual growth rates have ranged from a low of 6 percent in 1975, a year in which the enrollment level was limited, to a high of 31 percent. The compound annual growth rate for the period 1975-81 is in excess of 15 percent. Two factors help explain the current leveling off of enrollment. First, the proportion of single subscribers continues to increase, now reaching 52 percent of all contracts. Second, the Harvard Community Health Plan competes with the MIT Health Plan for members. Neither explanation is complete, however, since the annual increase in contracts was 4.6 percent in 1981, less than half the previous annual growth rate, and there are fewer than 200 Harvard Community Health Plan contracts at MIT.

Even to stand in place, however, requires a substantial number of new MIT Health Plan contracts. There were 1,266 new subscribers enrolled last year; the turnover rate was 32 percent. It is gratifying to know that virtually all employees who left the MIT Health Plan did so because they left MIT. It is also important to note that a majority of new employees on campus selected the MIT Health Plan. A recent survey showed that 61 percent of all new employees on campus, 34 percent of new employees at Lincoln Laboratory, and 59 percent of new faculty members joined the MIT Health Plan.

The leveling of enrollment was combined with a very large increase in hospital inpatient and outpatient expenses, resulting in a loss of 15 percent this year. This loss has caused us to examine and modify the control mechanisms operating in this area, as noted elsewhere in this report.

The MIT Health Plan management has been strengthened greatly by consolidating the student and MIT Health Plan administrative efforts under the leadership of Linda L. Rounds who was appointed assistant director, Finance and MIT Health Plan. With the able effort of Marie T. Jean, who became senior claims manager, the claims management program has been improved. Gioia M. Morongell has joined the staff to manage enrollment services for both plans.

During the year, Sally Wright was appointed manager of Ambulatory Support Services. Her familiarity with Department personnel and experience in personnel matters greatly strengthens our ability to manage our increasingly complex operation.

Our efforts to provide a field setting for management students continued with the employment of two students -- one MIT undergraduate and one Harvard Business School graduate student -- as summer management interns. A patient feedback survey was undertaken and completed by these...
Vice President and Dean of the Graduate School

students and the results shared with the Department’s Executive Committee and consumer advisory board. Changes have been made in response to the report. This coming year, we hope to employ three students during the summer months as management students.

The comparative brevity of this report is not only a reflection of the undersigned’s wish to spare the reader, but also of the fact that the Division of Comparative Medicine (formerly Division of Laboratory Animal Medicine) is no longer a service within this Department.

MELVIN H. RODMAN, M.D.

Division of Comparative Medicine

At the beginning of the academic year, MIT’s Division of Laboratory Animal Medicine (DLAM) was renamed the Division of Comparative Medicine (DCM) to reflect a growing emphasis on research and teaching in the area of animal diseases analogous to diseases in humans, and the use of animals at MIT to understand basic disease mechanisms. Simultaneously our reporting structure was modified; we now report directly to the Vice President and Dean of the Graduate School.

The Division of Comparative Medicine is responsible for the total animal health care delivery system at MIT. The Division also provides professional and technical diagnostic and veterinary expertise for several neighboring research institutions. The Division continues to seek advice from a presidentially appointed Animal Care Committee, consisting of faculty from various departments which utilize animals for research. The Division relates to over 150 principal investigators, their associates and graduate students. The animal-related research involves faculty members in 10 departments or separate MIT research laboratories. Animal-related research activities at MIT amounted to $8.5 million in fiscal year 1980.

The Division purchases and produces approximately 100,000 animals annually, and is also responsible for the health monitoring of an additional estimated 300,000 animals on an annual basis. MIT maintains 12,000–15,000 animals on a daily basis; this number will expand to 17,000–20,000 with the opening of the 15,000 sq. ft. Health Sciences and Technology animal facility. Also, the Research Animal Diagnostic Laboratory (RADL) is responsible for diagnostic services for over 81,500 animals on a daily basis.

A tabular review of building renovation costs for the laboratory animal physical facilities since the initiation of centralized animal care seven years ago is attached (Appendix I). During this period, we have phased out two smaller satellite facilities in Buildings 16 and 37 and incorporated the space into larger animal care units. Total space managed by DCM encompasses over 65,000 gross square feet located in eight satellite facilities. Buildings 56 and 16, and E17-E18 are operated as contiguous units. The Psychology E10 animal care facility is the only unit carried on the DCM inventory that is substandard. This deficiency is being partly alleviated by moving several investigators who use this facility into the new Health Sciences and Technology space. However, E10 will continue to house animals. A resolution as to the fate of this facility must be addressed within the next year.

I am pleased to report that the MIT animal care program site was visited in April 1981 by the accreditation board of the American Association for the Accreditation of Laboratory Animal Care (AAALAC). A full accreditation with commendation resulted.

Our Research Animal Diagnostic Laboratory (RADL) has now been in operation five years. The funds for operating this laboratory are generated from a National Institutes of Health (NIH) grant and from services provided to several outside research institutions in the Boston area. DCM has submitted to NIH a competing five-year renewal for this grant. This unit continues to provide diagnostic coverage for the Institute and Boston community.

The Boston area is noted for its high density of biomedical research-oriented institutions. Many of these facilities have extensive animal-related research programs, but unfortunately do not have access to an animal diagnostic laboratory. In January 1977 the RADL began offering its services.
Division of Comparative Medicine

to several research institutions as a regional diagnostic resource. To date, 13 of these facilities have utilized the diagnostic services of RADL on a regular and continuing basis. Other facilities have requested and received diagnostic support to ascertain the cause of specific disease outbreaks. Six of the 13 institutions have AAALAC accreditation; the remaining seven are actively upgrading their programs in order to apply for accreditation. The diagnostic laboratory resources are provided on a fee-for-service basis.

The Division remains active in teaching undergraduate, graduate, and summer veterinary students. The staff continues to offer the course entitled Laboratory Animals: Usage in Biomedical Experimentation. This year we also participated in teaching a core course for graduate students entitled Analytical Practices in Biochemistry: A series of techniques basic to analytical biochemistry. The staff also teaches a third course in Nutrition Pathology. We are involved as well in the Undergraduate Research Opportunities Program at MIT, and during the summer of 1980, DCM also tutored three veterinary students.

Independent and collaborative research programs continue to be active and growing. The Division staff has successfully completed clinical and collaborative investigation, pilot research experiments, and critical reviews resulting in 10 published articles during the past year. DCM also has another four articles in press. The staff has presented five papers as invited speakers at symposia, national meetings, and university-sponsored lectures.

At present, DCM has six funded grants or contracts where DCM staff are either principal investigators or co-principal investigators.

Finally, I am pleased to report several additions to our staff: Carolyn A. Wish joined our laboratory staff in October as certified medical technologist; Eugene Freeman will be joining the Division staff on July 1, 1981, as histologist; Dr. Christian E. Newcomer will join our staff on July 15, 1981, as clinical veterinarian with additional active interests in research and teaching; and Dr. Carolyn E. Craft will join the staff of the Division on August 15, 1981, as comparative pathologist.

JAMES G. FOX
## APPENDIX I

### ANIMAL FACILITIES: Renovation and New Construction Costs

The following table summarizes cost estimates of Renovation and Building Program (1975 dollars, actual current dollars)

<table>
<thead>
<tr>
<th>Building</th>
<th>56</th>
<th>16</th>
<th>E18</th>
<th>45</th>
<th>E20</th>
<th>E10</th>
<th>E17</th>
<th>37</th>
<th>HST</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Square Feet</td>
<td>13,000</td>
<td>1,900</td>
<td>7,200</td>
<td>13,000</td>
<td>2,544</td>
<td>5,100</td>
<td>3,680</td>
<td>1,559</td>
<td>17,000</td>
<td>64,983</td>
</tr>
<tr>
<td>Net Square Feet</td>
<td>7,190</td>
<td>1,205</td>
<td>5,385</td>
<td>3,960</td>
<td>2,100</td>
<td>3,930</td>
<td>2,965</td>
<td>1,555</td>
<td>10,000</td>
<td>43,290</td>
</tr>
<tr>
<td>Estimate (1975 dollars)</td>
<td>812,000</td>
<td>240,000</td>
<td>942,000</td>
<td>750,000</td>
<td>660,000</td>
<td>90,000</td>
<td>3,494,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual Costs (current dollars)</td>
<td>1,898,000</td>
<td>140,000</td>
<td>1,625,000</td>
<td>1,600,000</td>
<td>400,000</td>
<td>2,720,000</td>
<td>7,983,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completion Date</td>
<td>July '79</td>
<td>Late '77</td>
<td>July '80</td>
<td>Jan. '78</td>
<td>2</td>
<td>3</td>
<td>Oct. '81</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grant Support (NCI/NIH)</td>
<td>850,000</td>
<td>75,000</td>
<td>649,000</td>
<td>--</td>
<td></td>
<td></td>
<td>1,574,000</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>MIT Costs</td>
<td>1,048,000</td>
<td>65,000</td>
<td>976,000</td>
<td>1,600,000</td>
<td></td>
<td></td>
<td>2,720,000</td>
<td>6,409,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. In addition, provided $75,000 fixed equipment for DCM animal facilities
2. Facility does not require renovation for immediate future, but life expectancy of building unknown
3. No renovations required
4. Building phased out in 1981
5. Based on 600 GSF
6. 1979 estimated (not included in total column) - not utilized because of phaseout plan
7. Based on 12,000 GSF
8. Based on $160.00 per GSF
REGISTRAR

All statistics on Registration and Staff in the following tables are given as of the fifth week of the Fall Term, except: 1943-44 as of August 2, 1943; 1944-45 as of November 27, 1944; and 1945-46 as of July 30, 1945.

**TABLE I STUDENT REGISTRATION SINCE THE FOUNDING OF THE INSTITUTE * **

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NUMBER OF STUDENTS</th>
<th>YEAR</th>
<th>NUMBER OF STUDENTS</th>
<th>YEAR</th>
<th>NUMBER OF STUDENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1865-66</td>
<td>72</td>
<td>1906-07</td>
<td>1,397</td>
<td>1946-47</td>
<td>5,172</td>
</tr>
<tr>
<td>1866-67</td>
<td>137</td>
<td>1907-08</td>
<td>1,415</td>
<td>1947-48</td>
<td>5,662</td>
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<tr>
<td>1867-68</td>
<td>167</td>
<td>1908-09</td>
<td>1,461</td>
<td>1948-49</td>
<td>5,433</td>
</tr>
<tr>
<td>1868-69</td>
<td>172</td>
<td>1909-10</td>
<td>1,479</td>
<td>1949-50</td>
<td>5,458</td>
</tr>
<tr>
<td>1869-70</td>
<td>206</td>
<td>1910-11</td>
<td>1,506</td>
<td>1950-51</td>
<td>5,171</td>
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<tr>
<td>1870-71</td>
<td>224</td>
<td>1911-12</td>
<td>1,559</td>
<td>1951-52</td>
<td>4,874</td>
</tr>
<tr>
<td>1871-72</td>
<td>261</td>
<td>1912-13</td>
<td>1,611</td>
<td>1952-53</td>
<td>5,074</td>
</tr>
<tr>
<td>1872-73</td>
<td>348</td>
<td>1913-14</td>
<td>1,685</td>
<td>1953-54</td>
<td>5,183</td>
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<tr>
<td>1873-74</td>
<td>276</td>
<td>1914-15</td>
<td>1,816</td>
<td>1954-55</td>
<td>5,348</td>
</tr>
<tr>
<td>1874-75</td>
<td>248</td>
<td>1915-16</td>
<td>1,900</td>
<td>1955-56</td>
<td>5,648</td>
</tr>
<tr>
<td>1875-76</td>
<td>255</td>
<td>1916-17</td>
<td>1,957</td>
<td>1956-57</td>
<td>6,000</td>
</tr>
<tr>
<td>1876-77</td>
<td>215</td>
<td>1917-18</td>
<td>1,698</td>
<td>1957-58</td>
<td>6,179</td>
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<tr>
<td>1877-78</td>
<td>194</td>
<td>1918-19</td>
<td>1,819</td>
<td>1958-59</td>
<td>6,259</td>
</tr>
<tr>
<td>1878-79</td>
<td>188</td>
<td>1919-20</td>
<td>3,078</td>
<td>1959-60</td>
<td>6,270</td>
</tr>
<tr>
<td>1879-80</td>
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*Students attending regular subjects from M.I.T. curricula.
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1 Also included in Table III
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1Included also in Table III
TABLE IV CONTINUED, FORMER, AND NEW STUDENTS

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| Health Sciences and Technology (HST) | -                              | 9                              | 3                               |

| Undesignated                        | 3                               |                                 |                                 |
| First Year                          | 3                               |                                 |                                 |

<p>| Grand Total                         | 304                             | 3,614                           | 770                             |</p>
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**Total United States** 1,009

**U. S. Territories and Dependencies**

- Puerto Rico, University of, Mayaguez 1

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- Akademia Ekonomezna W Poznaniu (Poland) 1
- Algiers, University of (Algeria) 1
- Argentina National College (Argentina) 1
- Asian Institute of Technology (Thailand) 1
- Aston in Birmingham, University of (England) 1
- Auckland, University of, (New Zealand) 1
- Australian National University (Australia) 1
- Bangladesh University of Engineering and Technology (Bangladesh) 1
- Birmingham, University of (England) 1
- Bogazieli Universitesi (Turkey) 1
- British Columbia, University of (Canada) 2
- Cairo University 2
- Calgary, University of (Canada) 1
- Cambridge, University of (England) 7
- Canterbury, University of (New Zealand) 3
- China University of Sciences and Technology (Peoples Republic of China) 1
- Chulalongkorn University (Thailand) 1
- Chung-Yuan College of Sciences and Engineering (Republic of China) 1
- City University, The (England) 1
- Concordia University (Canada) 1
- Daeaa University (Bangladesh) 1
- Dae Hag Gyo (Republic of Korea) 1
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- Ecole Centrale de Paris (France) 1
- Ecole Centrale des Arts et Manufactures (France) 4
- Ecole des Mines de Paris (France) 1
- Ecole National des Points et Chaussées (France) 5
- Ecole Nationale des travaux Publics de l'Etat Vaux en velin (France) 1
- Ecole Nationale Superieure d'Architecture et des Arts Visuels (Belgium) 1
- Ecole Nationale Superieure de la Metallurgie et de l'Industrie des Mines de Nancy (France) 1
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- Ecole Superieure d'lngenieur en Electrotechnique et en Electronique (France) 1
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- Exeter, University of (England) 1
- Feng Chia College of Engineering and Business (Republic of China) 1
- Glasgow, University of (Scotland) 1
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- Ha'Universita Ha'ivrit Birkshulayim (Israel) 1
1 Graduates of 220 Colleges and Universities, including U. S. Territories and Dependencies in the United States and 159 Foreign Colleges and Universities.
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Awarded jointly with Woods Hole Oceanographic Institution

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<td>163 221 547</td>
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TABLE IX  NUMBER OF DEGREES OF BACHELOR OF SCIENCE AWARDED

All statistics are arranged by schools as of the current year. During the years 1868-1949 the general divisions were Architecture, Engineering, and Science. In 1950 the School of Humanities and Social Studies was established, and in 1951 the School of Industrial Management (after 1963 the Alfred P. Sloan School of Management) was added.

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<tr>
<td>Total</td>
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<tr>
<td>Total</td>
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SCHOOL OF ARCHITECTURE AND PLANNING

- Aeronautics and Astronautics
  - Undesignated
  - Building Engineering and Construction
  - Chemical Engineering
  - Chemical Engineering Practice
  - Civil Engineering
  - Undesignated
  - Electrical Engineering
  - Electrochemical Engineering
  - General Engineering
  - Materials Science and Engineering
  - Mechanical Engineering
  - Undesignated
  - Military Engineering
  - Mining Engineering and Metallurgy
  - Naval Architecture and Marine Engineering
  - Nuclear Engineering
  - Ocean Engineering
  - Undesignated
  - Sanitary Engineering

<p>| Total | 25      | 168     | 369      | 1,157    | 1,846    | 2,378    | 3,888    | 3,179    | 4,791    | 4,967    | 4,012    | 4,854    | 622      | 32,256   | 465      | 545      | 693      | 678      | 622      |</p>
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<tr>
<td>Total</td>
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| Grand Total                           | 812   |

*Includes only February and June degrees.
*Two received the degree in Naval Architecture, Course XIII-B. 1916 and three in 1917.
*Prior to 1923 degrees were awarded in Architecture.
*Prior to 1923 degrees were awarded in Mining Engineering and Metallurgy, changed from Metallurgy to Metallurgy and Materials Science.
*Includes only February and June degrees.
*These courses were included in Economics, Politics and Social Science, changed from Metallurgy to Metallurgy and Materials Science.
*Includes only February and June degrees.
*Includes only February and June degrees.
*Includes only February and June degrees.
*Includes only February and June degrees.
*Includes only February and June degrees.
*Includes only February and June degrees.
*Includes only February and June degrees.

See also Table XI for a list of courses offered in 1916-1917.

See also Table XII for a list of courses offered in 1918-1919.

See also Table XIII for a list of courses offered in 1920-1921.

See also Table XIV for a list of courses offered in 1922-1923.

See also Table XV for a list of courses offered in 1923-1924.

See also Table XVI for a list of courses offered in 1924-1925.

See also Table XVII for a list of courses offered in 1925-1926.

See also Table XVIII for a list of courses offered in 1926-1927.

See also Table XIX for a list of courses offered in 1927-1928.

See also Table XX for a list of courses offered in 1928-1929.

See also Table XXI for a list of courses offered in 1929-1930.

See also Table XXII for a list of courses offered in 1930-1931.

See also Table XXIII for a list of courses offered in 1931-1932.

See also Table XXIV for a list of courses offered in 1932-1933.

See also Table XXV for a list of courses offered in 1933-1934.

See also Table XXVI for a list of courses offered in 1934-1935.

See also Table XXVII for a list of courses offered in 1935-1936.

See also Table XXVIII for a list of courses offered in 1936-1937.

See also Table XXIX for a list of courses offered in 1937-1938.

See also Table XXX for a list of courses offered in 1938-1939.

See also Table XXXI for a list of courses offered in 1939-1940.

See also Table XXXII for a list of courses offered in 1940-1941.

See also Table XXXIII for a list of courses offered in 1941-1942.

See also Table XXXIV for a list of courses offered in 1942-1943.

See also Table XXXV for a list of courses offered in 1943-1944.

See also Table XXXVI for a list of courses offered in 1944-1945.

See also Table XXXVII for a list of courses offered in 1945-1946.

See also Table XXXVIII for a list of courses offered in 1946-1947.

See also Table XXXIX for a list of courses offered in 1947-1948.

See also Table XXX for a list of courses offered in 1948-1949.

See also Table XXXI for a list of courses offered in 1949-1950.

See also Table XXXII for a list of courses offered in 1950-1951.

See also Table XXXIII for a list of courses offered in 1951-1952.

See also Table XXXIV for a list of courses offered in 1952-1953.

See also Table XXXV for a list of courses offered in 1953-1954.

See also Table XXXVI for a list of courses offered in 1954-1955.

See also Table XXXVII for a list of courses offered in 1955-1956.

See also Table XXXVIII for a list of courses offered in 1956-1957.

See also Table XXXIX for a list of courses offered in 1957-1958.

See also Table XXX for a list of courses offered in 1958-1959.

See also Table XXXI for a list of courses offered in 1959-1960.
TABLE X  NUMBER OF DEGREES OF MASTER OF SCIENCE AWARDED

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*Note: The data represents the number of degrees awarded in each category by decade and calendar year since 1977.*
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Note: The table above represents the number of degrees awarded in various disciplines and fields at the School of Humanities and Social Science. The data is presented for the years 1950 to 1965, with each discipline listed and the number of degrees awarded each year. The total degrees awarded in each year are also provided at the bottom of the table.
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*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

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Awarded jointly with Woods Hole Oceanographic Institution

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\(^*\)Includes only February and June degrees
\(^1\)Prior to 1969 Aeronautical Engineer
\(^2\)Degree discontinued after 1955
\(^3\)Degree discontinued after 1964
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### ALFRED P. SLOAN SCHOOL OF MANAGEMENT

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### SCHOOL OF SCIENCE

| Biology | - | 1 | 10 | 17 | 21 | 38 | 105 | 167 | 8 | 267 | 19 | 19 | 17 | 14 | 8 |
| Chemistry | 7 | 19 | 59 | 146 | 180 | 342 | 427 | 406 | 28 | 1,614 | 33 | 25 | 37 | 32 | 28 |
| Earth and Planetary Sciences<sup>4</sup> | 1 | 7 | 10 | 22 | 20 | 71 | 84 | 99 | 14 | 328 | 6 | 17 | 11 | 8 | 14 |
| Mathematics | - | - | 6 | 25 | 35 | 70 | 211 | 231 | 18 | 596 | 28 | 23 | 19 | 20 | 18 |
| Meteorology and Physical Oceanography<sup>10</sup> | - | - | - | - | - | 14 | 45 | 35 | 1 | 95 | 2 | 2 | 2 | 3 | 2 |
| Nutrition and Food Science | - | - | - | - | - | 4 | 28 | 66 | 156 | 12 | 266 | 17 | 18 | 23 | 23 | 12 |
| Oceanography<sup>5</sup> | - | - | - | - | - | 11 | - | - | 11 | - | - | - | - | - |
| Physics | - | 2 | 6 | 48 | 159 | 283 | 390 | 383 | 25 | 1,296 | 36 | 33 | 39 | 27 | 25 |
| **Total** | 8 | 29 | 91 | 258 | 419 | 846 | 1,339 | 1,477 | 106 | 4,573 | 141 | 137 | 148 | 127 | 106 |

Awarded jointly with Woods Hole Oceanographic Institution

| Biology | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Earth and Planetary Sciences | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Electrical Engineering and Computer Science | - | - | - | - | - | - | 4 | 47 | 3 | 54 | 6 | 3 | 3 | 13 | 3 |
| Meteorology and Physical Oceanography<sup>10</sup> | - | - | - | - | - | - | 1 | 15 | 1 | 17 | 2 | 1 | 1 | 1 | 1 |
| Ocean Engineering | - | - | - | - | - | - | - | 6 | - | 6 | 2 | 2 | - | - | - |
| **Total** | - | - | - | - | - | - | 5 | 83 | 5 | 93 | 12 | 9 | 5 | 18 | 5 |
| **Grand Total** | 8 | 29 | 91 | 258 | 447 | 979 | 2,504 | 3,327 | 261 | 7,904 | 332 | 345 | 339 | 326 | 261 |

---

*Includes only February and June degrees
*Previously included in Industrial Economics
<sup>1</sup>Changed from Industrial Economics to Economics 1966
<sup>2</sup>Changed from Industrial Management to Management 1967
<sup>3</sup>Includes Ceramics; Metallurgy and Materials Science changed to Material Science and Engineering 1975
<sup>4</sup>Changed from Geology and Geophysics to Earth and Planetary Sciences 1970
<sup>5</sup>Beginning 1967-68 included in Earth and Planetary Sciences or Meteorology
<sup>6</sup>Changed from City and Regional Planning to Urban Studies and Planning 1969
<sup>7</sup>Prior to 1960 Aeronautical Engineering
<sup>8</sup>Changed from Naval Architecture and Marine Engineering to Ocean Engineering 1971
<sup>9</sup>Changed from Electrical Engineering to Electrical Engineering and Computer Science 1975
<sup>10</sup>Changed from Meteorology to Meteorology and Physical Oceanography 1981
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**Awarded jointly with Woods Hole Oceanographic Institution**

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<td>-</td>
<td>8</td>
<td>1</td>
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<td>2</td>
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**Grand Total**

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<td>7</td>
<td>72</td>
<td>214</td>
<td>364</td>
<td>723</td>
<td>871</td>
<td>560</td>
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</tr>
</tbody>
</table>

1 Includes only February and June degrees
2 Prior to 1960 Aeronautical Engineering
3 Changed from Geology and Geophysics to Earth and Planetary Sciences 1970
4 Beginning 1967-68 included in Earth and Planetary Sciences or Meteorology and Physical Oceanography
5 Changed from Naval Architecture and Marine Engineering to Ocean Engineering 1970
6 Changed from Geological Engineering to Electrical Engineering and Computer Science 1975
7 Changed from Metallurgy and Materials Science to Materials Science and Engineering 1979
8 Changed from Meteorology to Meteorology and Physical Oceanography 1981
TABLE XV SUMMARY OF DEGREES AWARDED
(1868-1981)

<table>
<thead>
<tr>
<th>Degree</th>
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<tr>
<td>Bachelor in Architecture (discontinued 1972)</td>
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<tr>
<td>Bachelor in City Planning (discontinued 1954)</td>
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<td>Bachelor of Science</td>
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<td>Master in Architecture (discontinued 1972)</td>
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<tr>
<td>Master in City Planning</td>
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<tr>
<td>Master in Public Health (discontinued 1944)</td>
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</tr>
<tr>
<td>Master of Architecture</td>
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<td>Master of Architecture in Advanced Studies</td>
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WARREN D. WELLS
Vice President in the Office of the President

The annual reports which follow account for the departmental activities in Student Affairs, Athletics, Admissions, Career Planning and Placement, Personnel, the News Office and Campus Information Services, the MIT Press, and the Quarter Century Club. Dr. Isaac Colbert, the Institute's Assistant Equal Opportunity Officer, has reported on the highlights of the MIT Affirmative Action program.

We cannot brag about our accomplishments in Affirmative Action over the past year. The numbers of minorities employed on the faculty and staff, and the numbers of minority students enrolled in our programs have not grown significantly; sadly, in some cases these numbers, particularly the numbers of black minorities, show a decline from last year. To address this problem, we tightened the requirements for serious search which precede appointments, and the monitoring of all new appointments by the Academic Council. The departments throughout the Institute responded to these measures with good will, but there has been no improvement in results. We are now making further efforts to better understand our own institutional culture and to devise more appropriate and, we hope, more effective means of achieving our goals.

As the Institute's Equal Opportunity Officer, I cannot guarantee future results. But I can say with full confidence that the commitment of the Institute's leadership has never been stronger, despite the talk in the national press about retrenchment, and the climate of increased conservatism that we experience on a local and national scale. President Paul E. Gray's Inaugural address, last fall, was a strong reaffirmation of MIT policy on equal opportunity and the affirmative action programs required to achieve it. We are committed to increasing the opportunities for learning and for personal and professional growth of all of our members, students, faculty, and staff. To achieve this goal we must continue to broaden the diversity of backgrounds and points of view represented in the MIT population. MIT will not be a leader, will not be what it wants to be in the future, if we fail to attract, to enroll, to hire, and to keep larger numbers of minority men and women. As we begin another academic year the challenge is once again before us. Hic Rodus, hic salta.

Last year at this time I reported on two important appointments, those of Dean Shirley McBay and Professor Royce Flippin, to head, respectively, Student Affairs and Athletics. Under their leadership during the last academic year, significant steps were taken to complete the organization and staffing of these two areas. Thus, we welcome at the end of the year several new colleagues to MIT and we welcome, as well, those who have been promoted to expanded responsibilities and have taken on new duties in the student service areas and in several sections of the Personnel Office.

Last year, I reported also on the beginnings of developing a group process, a team leadership effort among the managers and senior staff that report to me. The purpose of the Vice President’s Staff Group, which met regularly throughout the academic year, is to bring our diverse perspectives and points of view to bear on the management of our areas and on our contribution to the formulation of Institute policies, particularly as these policies affect MIT people. I am very gratified by the progress and achievements of this team approach to date. I note, especially, the effort we began in June of this year to develop and apply a form of systematic planning suitable to our own responsibilities. To do this we have borrowed from corporate planning models, and have used the notion of Strategic Planning Unit to apply to each office within my areas of responsibility.

Our aim is a combination of a systematic approach at long-range planning and a continuing sensitivity to the changing needs for human services in the Institute community. We believe that such a dual focus on short- and long-term institutional needs will provide a balanced response at a time of increasing demands and increasing complexity on one hand, and of tightening constraints in fiscal and other resources on the other hand. This form of creative management will continue to require reviews, questioning, and reconceptualization of what we do, how we do it, and most importantly, why.
In this context, our planning work this summer represents an intensive commitment of effort now on long-term directions and objectives, rather than a preoccupation with solutions to the more immediate problems of this or next year. I believe that developing goals and program planning will find us better prepared to face short-term challenges and fiscal prospects, whether they encourage future growth of services or whether they require modest or even drastic cutbacks. This premise has yet to be tested and the outcome of the test will decide whether long-range planning can be seen as a worthwhile management activity, or as an interesting but inconsequential exercise.

C.B. SIMONIDES

Affirmative Action Program

The implementation of a revised Serious Search policy was emphasized during the past year. Examination and discussion of the Institute's uneven performance in recent years with respect to the employment of minorities and women at all levels highlighted the need for better guidance to departments in their search efforts. The objective of the revised policy is to provide several opportunities for input during searches to ensure that minority and female employment pools are reached. While it is still too early to fully assess the efficacy of the revised policy, we are encouraged that searches are casting a broader net, and that opportunities for employment at MIT are becoming more widely known throughout minority and female professional communities.

In the past year, the MIT Affirmative Action Plan was revised and updated to reflect current regulatory requirements as well as internal policy changes. A summary of the revision was distributed to the Institute community in a Tech Talk supplement. Among the significant policy changes included in the revised plan were a new policy on harassment, a revised grievance procedure, and a policy on flexible working hours.

Following extensive revisions to the MIT Guide for the Handicapped, which now reflects the substantial physical improvements in campus accessibility, the handicapped plan was published for the first time. In addition, an ad hoc advisory committee was formed to discuss and recommend improvements in the delivery of Institute services to handicapped students and employees. Members of the committee have been compiling a handicapped resources brochure, which they plan to complete and distribute next year.

Other activities of the past year have focused on our concern with the future of Federal affirmative action and equal opportunity enforcement policy as it affects higher education, and with the continuation and reaffirmation of MIT's commitment with respect to these educational and employment opportunities. As part of the Reagan Administration's program to curtail Federal regulatory requirements on business and industry, including higher education, MIT was among those asked to comment upon specific regulations and their effects on colleges and minorities. We are concerned by what appears to be a retreat from the posture of vigorous Federal support for the enforcement of equal opportunity regulations. Nevertheless, the Institute will continue to pursue its internally defined objectives and will continue to seek increased diversity among its students and employees. The Equal Opportunity Office Staff Group was formed to share information and ideas on a regular basis and to more effectively plan for and coordinate our future efforts.

Finally, Kevin E. Lonnie, a graduate student in management at the Sloan School, spent a year as a research assistant in the Equal Opportunity Office. In addition to assisting with the extensive revisions of the Affirmative Action Plan, Mr. Lonnie conducted research toward the completion of a master's thesis.

ISAAC M. COLBERT
At the end of the 1980-81 academic year, the Office of the Dean for Student Affairs (ODSA) completed its second year of operation under a new organizational structure resulting from a year-long review of student services. This review was under the direction of Vice President Constantine B. Simonides.

While the new structure has worked well, some changes were made during the past year that were primarily designed to improve services to students, give more responsibility to sections of the Office, and place increased emphasis on general staff development. The major changes are listed below.

1) The positions of "section heads" were created involving Associate Deans Robert Holden and Robert Sherwood, who already had responsibility for the respective areas of Student Activities and Residence Programs, and the internal promotions of Assistant Deans Holliday Heine and Robert M. Randolph to Associate Deans and respective heads of the Undergraduate Academic Support Section and the Student Assistance Services Section.

2) A half-time Assistant Dean's position in the Residence Programs Section was upgraded to a full-time position in order to improve services to graduate students and increase long-range planning capability. Dr. Peter H. Brown was appointed to this position in March 1981.

3) A half-time staff position in the Student Assistance Services Section was created to allow for program development in such areas as substance abuse (drugs, alcohol), sexuality and relations, and counseling services to graduate students. This position was filled by Jeannette Gerson in May 1981.

4) Program, staff, and budgetary responsibilities were delegated to section heads.

5) The responsibilities of the Student Activities Section were expanded to include the coordination of programs of interest to women students and the provision of staff support to the Graduate Student Council.

6) Sectional goals and objectives and the identification of 1980-81 priority areas for the Office were established.

7) Increased emphasis was placed on staff development and office automation through a) enrollment of several staff members in development courses and training programs, b) the establishment of an invited guest series involving various academic and administrative persons at the Institute, and c) the acquisition of a word processor.

During the year, Assistant Dean Bonny Kellermann resigned her position in the Student Assistance Services Section in order to assume the position of director of the MIT Educational Council. Following a search for Dean Kellermann's replacement, Linda Vaughan of the Harvard School of Public Health was appointed to the position, effective August 1981. Dean Susan Haigh Houpt resigned as preprofessional advisor in May.

In addition to the activities taking place within the various sections of the Office, which are described in the remainder of this report, the staff prepared for and participated in two other major activities during the year. These were a visit to the campus by the Office's Visiting Committee on May 7-9, and a major planning effort begun in June that included an all-day meeting held on June 26.

In keeping with our interests, the Visiting Committee on Student Affairs focused on the Office's role in the academic support program at the Institute, with a special review of activities in the
Undergraduate Academic Support (UAS) Section. While we are awaiting the formal report, the Committee indicated general praise during its visit for current UAS programs and support for most of our recommendations regarding an expanded UAS role in academically oriented activities. The Committee discussed in detail several issues raised by students and others regarding the Office. Among these issues are those listed below.

- Programming within the Student Activities Section of the Office
- The role of the Dean for Student Affairs as an "advocate" for students
- Faculty advising, especially regarding subjects in the Humanities and Social Sciences
- Student representation on the Academic Council
- The Dean for Student Affairs as an ex officio member of the Committee on Educational Policy
- The question of whether the Dean for Student Affairs should report to the Provost or continue reporting to the Vice President

Planning efforts during the month of June involved refining our overall goals and objectives as well as those of the various sections, and examining in depth the activities in which we will be involved next year as we try to achieve our collective objectives. The planning meeting held on June 26 focused primarily on the Student Activities and Undergraduate Academic Support sections of the Office as a follow-up to the Visiting Committee’s evaluation in May.

In order to increase student interaction with the Office, and with the Dean for Student Affairs in particular, a series of Thursday evening visits to various Institute houses and Independent Living Groups is being planned as well as several "special issues" meetings in the Student Center on such topics as tuition, room and board rates, and financial aid.

Overall, we have had a very productive year. This was due in great measure to the hard work and cooperation of the entire staff, to student support of and participation in various activities of the Office, and to the advice and support of the Office’s several advisory groups, especially the Committee on Student Affairs. Communication between our Office and other service areas, specifically the Psychiatric Service and Campus Patrol, was excellent. The monthly meetings with the faculty residents were especially stimulating and productive.

On a more personal note, I found the weekly meetings with the Vice President to be of great value during my first full year at MIT. Many other individuals at the Institute were generous with their time and advice as we sought to improve services to students.

SHIRLEY M. MCBAY

UNDERGRADUATE ACADEMIC SUPPORT

The Undergraduate Academic Support (UAS) Section serves as an academic information center for students, individual faculty members, and departments, and as a catalyst for information exchange among departments. Our interaction with the academic subgroup of the Faculty Committee on Student Affairs has contributed significantly to the Section's success in this role and has borne out the importance of close ties with the faculty. The major UAS programs are described below.

Freshman Advising Program

The primary counseling of freshmen during 1980-81 was done by 282 advisors (143 faculty, 81 staff, 22 lecturers/instructors, and 16 graduate students). While it was again quite an effort to recruit a significant number of faculty to serve as freshman advisors, we continue to feel it critical to provide freshmen with this important professional contact.
We continued to have an abundance of undergraduates applying for the "associate advisor" positions. These students are an important component of the advising system, for they can provide current information on the academic and social realities of undergraduate life at MIT.

The experimental Baker House advising program, which matched seven freshman advisors with approximately 35 freshmen in Baker House, continued for a second year. The advisees were especially positive about the informal availability of associate advisors in their living group.

During the year the Section was in communication with advisors by mail and through a series of luncheons in the fall. This mode, while somewhat expensive, provided the only personal contact the staff had with the advisors. The meetings provided valuable feedback about individual students and about how UAS was viewed by advisors.

Contact with the students was maintained primarily through the nine issues of the Freshman Newsletter produced during the academic year. This two-page publication, which will be continued next academic year, provides information not only from UAS but also from departments that depend on the newsletter to help them make contact with the freshmen.

The Freshman Handbook continues to be used as a major mechanism for supplying information to students and advisors. This book undergoes substantial revision every spring and consequently has become a very time-consuming operation.

UAS again processed the required freshman evaluation forms that are completed for each freshman at the middle and end of each term.

Fifteen freshmen withdrew for a variety of personal reasons during the academic year. Eleven additional freshmen were required to withdraw for at least one term because of unsatisfactory academic performance. The table below summarizes for the past four years the number of required withdrawals, the number of formal warnings of unsatisfactory performance given by the Committee on Academic Performance ("CAP Warnings"), and the number of the more informal letters from our office suggesting that the student review his or her performance.

<table>
<thead>
<tr>
<th>Academic Year</th>
<th>Required Withdrawals</th>
<th>CAP Warnings</th>
<th>UAS Letters</th>
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<td>1980-81</td>
<td>11</td>
<td>104</td>
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<td>1979-80</td>
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</tr>
<tr>
<td>1977-78</td>
<td>13</td>
<td>113</td>
<td>80</td>
</tr>
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</table>

The Undesignated Sophomore Advising Program

The number of students choosing not to declare a major for some portion of their sophomore year increased this past year, while the number of advisors decreased. Twenty-nine volunteer advisors drawn from faculty and staff were needed to provide a reasonable match of interests with 99 undesignated sophomores at the beginning of the fall semester and 64 in the spring. The respective student figures for 1979-80 were 74 and 42 for the fall and spring terms. These students were assisted by 45 volunteer advisors that year.

Preprofessional Advising and Education

The Preprofessional Advising and Education component of UAS continued to serve as a focal point for students interested in careers in medicine, law, or allied fields, and who, without our help, would have no particular department to support their applications to professional schools. The staff worked closely with members of the faculty who served on the Committee on Preprofessional Advising and Education, the Premedical Advisory Council, and the Prelaw Advisory Council.

Meetings to impart information and advice to students were scheduled throughout the year.
Professor Bernard Gould, chairman of the Premedical Advisory Council, and Professor Daniel Nyhart, chairman of the Prelaw Advisory Council, were the principal speakers at these sessions, where such issues as the application/admission process to professional schools, the admission tests (LSAT, MCAT), requirements for admission, and availability of the faculty advisory councils were addressed. In addition, members of admission committees from seven medical and law schools visited MIT for the express purpose of attracting students from MIT to their programs.

For the last five years the number of seniors applying to medical school has remained constant at approximately 10 percent of each graduating class. In past years, 83-85 percent of these applicants were successful in gaining admission to medical school. This year 100 fourth-year students submitted applications to medical school. We expect they will have the same rate of success as previous classes. The number applying to law school has declined by 45 percent since 1979 when 35 students submitted applications. This year, 24 students applied to law school. We suspect this decline is due to students seeing increased job opportunities in other fields and a tightened job market for lawyers.

The staff recently completed a mailing of 575 questionnaires to alumni who are currently attending medical and law school. Responses will provide a valuable resource to our students as they learn about the nature of professional education. In addition, the prelaw handbook is currently being revised. Members of the Prelaw Advisory Council have contributed to the new edition, which is expected to be printed during the summer of 1981.

With the tightening of available financial aid resources, a major focus will be to help students identify and pursue sources of financial assistance for graduate study.

Administrative Support to the Committee on Academic Performance

The Committee on Academic Performance (CAP), the standing committee of the faculty charged with reviewing the academic records of all undergraduates at the end of each term and taking appropriate action in the name of the faculty, was chaired again this year by Professor Alar Toomre. E. Jane Dickson continued to serve as assistant to the chairman. During the year, the CAP handled approximately 500 petitions from individual students requesting exceptions to certain regulations of the faculty.

Through constant interaction with students and faculty, the CAP support office has evolved into an information center for academically related policies and procedures. The Committee continued its interactions with the counseling resources of the ODSA, both as a referral service for counseling and for input on particular students as background for the Committee's decisions. An updated version of the Committee's valuable reference, A Guide to Undergraduate and Faculty Advisors, was published in September 1980.

The Undergraduate Seminar Program

The Undergraduate Seminar Program showed an increase in the number of offerings this past year in the fall semester (from 50 to 54) and in the spring semester (from 34 to 37). The large number of students who choose to participate in the program continues to indicate that these seminars provide an important addition to MIT's curriculum. Approximately 715 students (of whom 522 were freshmen) participated in seminars in the spring.

Additional ways to increase the visibility of the Seminar Program to both faculty and students are being developed. The seminar booklet is now issued twice a year, and a brochure is being prepared to inform faculty and departments about the merits of the Seminar Program. Other special publicity activities were carried out this year, including a 20th anniversary party held in Lobby 10 during IAP. However, unless we are able to entice the faculty to continue participation in this program through some form of "reward system," or to revise the scope of the program significantly so that it becomes more attractive to faculty members, the program will suffer under increased burdens on participating faculty.

Professor Michael Driscoll has continued as faculty chairman of the Undergraduate Seminar Program and Peggy Richardson as executive officer.
Dean for Student Affairs

Academic Support and Information Center

The activities in this area are some of the most exciting, as they represent progress the Section is making in expanding its role beyond that of a freshman office. Efforts have been made to address the problem of finding ways to increase ODSA contact and communications with academic departments. There was a series of meetings with staff from the undergraduate departmental offices and UAS staff this year. These meetings have been used by our staff to encourage a strong undergraduate support system for the benefit of both students and faculty advisors. They have served to provide both information from and feedback to all ODSA services and other administrative offices. The meetings also provided an opportunity to inform departments with less than adequate student support systems of effective support activities within other departments.

As students from all classes have become more aware of the services provided by UAS, they are coming in more often with questions about academic procedures.

Examples of ways in which UAS facilitated other academic projects last year are as follows:

1) Coordinating a "linked scheduling" experiment this past fall between certain mathematics and physics recitation sections. Current plans call for a continuation of this experiment this fall.

2) Working with a student who was trying to develop an audience feedback system in Room 26-100.

3) Supporting the undergraduate members of the Student Committee on Educational Policy (SCEP) in their efforts to establish a Student Subject Evaluation System. Here UAS offers administrative support, and in the more sensitive issues dealing with form, content, or editorial license, the staff involves departmental faculty, the Provost's Office, and the academic subgroup of the Committee on Student Affairs.

4) Providing staff support to the Committee on Educational Policy as it evaluates the curriculum demands on students.

5) Assisting in the preparation of a booklet to help recitation instructors, particularly graduate teaching assistants, with their teaching. This booklet, a combined effort among a number of faculty, staff, and graduate students, will be distributed to departments this coming fall.

6) Sponsoring a series of study skills workshops which train interested undergraduate and graduate students to run seminars or to help students individually. Participants presented what they learned to less experienced students in a series of study skills seminars offered in the fall and spring terms and during the Independent Activities Period (IAP).

Career and Course Orientation

Several activities designed to help students make decisions regarding departmental majors and career directions were carried out. Trailblazing, a series of seminars jointly sponsored by the Alumni Association, the Career Planning and Placement Office, the Undergraduate Association, and the UAS Section, was conducted again this year. We invited other alumni during IAP to speak to undergraduates about their career paths in a setting designed to illustrate the flexibility of an undergraduate degree from MIT.

Other activities in this area involved providing students with information about departmental open houses and helping the departments with plans for open houses and other activities to attract students as majors in the departments.

Supervision and Coordination of Residence/orientation (R/O)

The Residence/orientation program, designed to welcome new students (especially freshmen), is produced almost entirely by undergraduates under the leadership of an R/O coordinator who is paid and "supervised" by the UAS. R/O Week 1980, under the coordination of Jeffrey Solof,
Vice President in the Office of the President

Class of 1981, expanded the activities for incoming women students and for parents visiting the campus during that week. Rhonda Peck, Class of 1982, is coordinating these efforts for the fall of 1981. During 1981-82, we hope to extend orientation throughout the freshman year.

Staff

Staff within the UAS served as ex officio members of the Committee on Curricula, the Committee on Undergraduate Admission and Financial Aid, and the Committee on Academic Performance. We held membership on the faculty/staff advisory committee to the Office of Minority Education and the IAP Administrative Committee. We also attended meetings chaired by Dean Robert Alberty for faculty teaching science requirement subjects taken by many freshmen. Staff members met regularly with the academic subgroup of the Committee on Student Affairs.

Major staff changes occurring this year included the move of Dean Holliday Heine from Student Assistance Services to the head of UAS, and the resignation of Dean Susan Haigh Houpt as preprofessional advisor.

HOLLIDAY C. HEINE
E. JANE DICKSON
SUSAN HAIGH HOUPT
PEGGY RICHARDSON

STUDENT ASSISTANCE SERVICES

Since Associate Dean Robert Randolph assumed responsibility for the Student Assistance Services (SAS) Section of the ODSA in August 1980, the Section has developed a set of clearly articulated goals along with a set of specific objectives for 1980-81. These two steps have resulted in substantially improved services to students and have enabled this Section to make significant contributions to efforts that address the priority areas identified for 1980-81 by the ODSA.

SAS Goals and Objectives

The goals of the SAS are the following:

- to counsel and advise graduate and undergraduate students on a wide range of personal, academic, and career matters;
- to broker information on a variety of issues by making appropriate referrals, e.g., to the Psychiatric Service, the Medical Department, Campus Patrol, academic departments, legal and financial offices, faculty members, and committees;
- to provide support services for minority, handicapped, and women students;
- to serve as a resource for those students who wish to study abroad for a period of time;
- to provide resources and support services for the international student community;
- to provide creative resources for special projects such as Nightline (a student-run telephone hotline) and the preparation of a booklet on human sexuality; and
- to assist in the monitoring of the living environment on campus.

Activities within SAS during 1980-81 were designed to accomplish the following objectives:

- facilitating the integration of the International Students' Office into SAS;
Dean for Student Affairs

- improving our visibility to the graduate community so that we can begin to serve as a resource for this large segment of the community;
- continuing to serve the counseling needs of the community while at the same time building our relationships with academic departments and other offices delivering student services;
- continuing as a counseling resource for both students and the Committee on Academic Performance when responding to academic problems; and
- offering effective support to members of special interest groups, e.g., Gays at MIT, the Black Student Union, and the Mexican-American Student Association.

Priorities within SAS during 1980-81 continued to be in terms of human services. Despite the staff being short one counseling dean since the first of the year, 2,172 student conferences had been held by the end of April. Each of the more than 1,800 international students passed through the office on at least one occasion during the past year.

Special counsel and support continued to be provided for various student groups including minority, handicapped, and gay students. Assistant Dean Mary Hope and other members of the staff participated in a variety of special activities such as the Leadership Conference for Undergraduate Women, the Black Students Science Symposium, the Black Student Union Lecture Series, and ongoing discussion groups for minority students.

In order to improve relations with the faculty, the section held a series of brief meetings to which all advisors of Course VI (Electrical Engineering and Computer Science) were invited. Attendance was excellent and conversations with faculty have already led to greater cooperation in working with students.

During IAP, SAS sponsored two seminars, one dealing with cross-cultural concerns and issues and the other with sexuality and personal relationships. The chairman of the Boston School Committee, John O'Bryant, was an invited participant in the first seminar. The second seminar drew on the resources of our Medical Department and the medical community in Boston.

Foreign Study

Katharine Cutting, administrative assistant for foreign study in SAS, spent the year organizing this activity and increasing its visibility to the MIT community. Her organizational efforts included improving existing files on study abroad, establishing separate files on work and travel abroad, and updating informational materials on hand through purchases and subscriptions.

She was able to improve services to students by 1) initiating information exchange activities involving returning students and students considering going abroad; 2) providing in-depth reviews of foreign study programs in Israel, Spain, France, England, and Germany; 3) using evaluations of programs by participating students; and 4) increasing cross-referencing of general community information on behalf of students inquiring about studying, traveling, or working abroad.

Efforts were also made to establish firm academically based support for foreign study. This has involved increasing faculty awareness, acceptance, involvement, and endorsement of foreign study; strengthening policy statements on the purpose of foreign study in program materials as well as the program selection process; improving the preparation for foreign experience through increased contact with appropriate departments; and creating an atmosphere where foreign study/experience and foreign languages are seen as mature and logical choices for an increasing number of students each year.

International Students

During 1980-81, the international student population at MIT consisted of more than 1,800 men and women students from over 90 nations. Some 1,500 are registered as graduate students and the remainder are undergraduates. In addition, there were approximately 500 dependent spouses within the Institute community.
Associate Dean Eugene Chamberlain and his staff continued to offer a number of services to international students. These included providing the essential travel documentation to approximately 700 foreign students who were selected for admission to undergraduate and graduate degree programs in anticipation of their arrival in September. The staff provided individual students, and often their spouses, with helpful information and orientation relative to settling in at MIT. They also assisted Dr. Charlotte Schwartz of the Medical Department in the operations of the annual International Open House. Other staff efforts included:

- Providing information to members of the faculty seeking assistance on credential evaluations of international students;
- Helping to coordinate the well-established English Language Evaluation Testing Program with members of the faculty;
- Assisting in coordinating activities of the Alumni Association in relation to on-campus services to international students as well as activities for overseas clubs;
- Coordinating inter-university relationships among groups of international students with the World Affairs Council of Boston;
- Acting as sponsor, in cooperation with the Athletic Department, for a group of international students participating in the Babson Olympics '81 sports program;
- Taking the lead in pulling together the *Practical Planning Guide for Graduate Students*;
- Cooperating with the MIT Host to International Students Program; and
- Chairing the Faculty Committee on Foreign Scholarships. Through this program, alumni of MIT study as Fulbright, Marshall, Churchill, or Deutscher Akademischer Austauschdienst scholars abroad.

Staff

Staff within the SAS continued to serve on various committees including the Committee on Discipline, the Committee on Graduate School Policy, the Athletic Board, and the Medical Advisory Board. Dean Bonny Kellermann resigned her position in January as Assistant Dean in SAS to assume the duties of Director of the Educational Council at MIT. She will be replaced by Linda Vaughan in August of this year. Jeannette Gerzon joined the staff in May as Assistant Dean on a half-time basis. Dean Hope has been out of the office due to an extended illness since April. We hope that she will be able to return to the staff during the month of July.

ROBERT M. RANDOLPH
ROBERT L. HALFMAN
EUGENE H. CHAMBERLAIN
MARY O. HOPE

STUDENT ACTIVITIES

The Student Activities Section, headed by Associate Dean Robert Holden, continued its traditional role of providing support to an increasing variety of student organizations, while its responsibilities expanded to include both the coordination of activities of special interest to women students and the provision of staff support to the Graduate Student Council. Among this year's ODSA priority areas, an interest was expressed in increasing our interactions with the Undergraduate Association and the Graduate Student Council, as well as in increasing the visibility of ODSA special support activities for women students. The program responsibilities described above for Student Activities have allowed the Office to make significant contributions in these areas of interest. In the following paragraphs, information is provided on the current status of student governance, the use of facilities, the Graduate Student Council, and on special activities in support of women students' interests.
The Undergraduate Association general elections, held this spring, perhaps provide some insight into the general status of undergraduate student community affairs. Not only was the voter turnout of approximately 45 percent of the student body the highest in 15 years, but the issues of student social interaction, participation in the affairs and structure of self-governance, increased communication and cooperation throughout the community, and the quality of student life were reflected throughout the campaign by the four teams of candidates for Undergraduate Association president and vice president.

The elections also indicated a high interest on the part of the four classes (1981-1984) in their leadership and the role of class organization and programming. In this regard, it is pertinent to note the continuing support and assistance of the Alumni Association in class affairs. Important bridges of understanding and mutual respect are being constructed.

Undergraduate government had an unusually productive year. The General Assembly continued to refine its organizational procedures and has become increasingly effective as a forum for the communication, understanding, and clarification of issues. An important agenda addition at regular meetings of the General Assembly was the inclusion of special guests such as President Gray, the Executive Committee of the Corporation, the Chairman of the Faculty, and members of various faculty committees. Meetings continued to be held at different locations around the campus and across the river.

The Finance Board of the Undergraduate Association handled all requests again this year for funds by both activities and student government groups using monies provided to the Association by the Dean for Student Affairs Office. The Board is responsible for assuring that all funds are used within set guidelines for the good of the academic and social life of the undergraduate student body.

The Finance Board was again responsible for funds that are provided as loans to student and community groups for the purchase of equipment or for special events. The Invested Reserve of the Finance Board was administered in conjunction with the Institute's Activities Development Board for the purchase of capital equipment by groups associated with the Institute.

The Nominations Committee continued its effective work of placing students on faculty and presidentially appointed committees. It produced, for the General Assembly and the community, an evening program highlighted by reports from students and faculty of the Committee on Curricula.

The 100 plus student activities that comprise the Association of Student Activities continued in a variety of ways to provide nourishment to the community and to individuals. Increasingly evident was activity programming by various nationality and minority groups.

Use of Facilities

With Kresge Auditorium available this fall, following a year-long renovation in which the roof covering was replaced, space for community programming again approached the level of prior years. It continued to be difficult, however, to accommodate the many demands within the community for this facility and for Walker Memorial, the Stratton Student Center, and the Burton Conner Dining Hall. Talbot House in South Pomfret, Vermont, continued to have full occupancy during term-time weekends and throughout IAP in January.

The MIT Chapel, together with the Religious Counselors Center on Memorial Drive, continued to be used for religious activities while also accommodating appropriate musical programs.

The Graduate Student Council

The Graduate Student Council (GSC) is the student government organization representing and serving graduate students at MIT. The Council is composed of one or two departmental representatives (depending on the full- and part-time student enrollment in a given department), a representative from each of the four graduate living groups, and one international student representative. Anne Gwinnett Prince of our staff provides support to the Council.

During this past year, the Council actively addressed four major concerns: a) tuition and financial aid, b) housing, c) affirmative action, and d) relocation of the GSC office. The
investigation of each of these concerns was delegated to appropriate subcommittees of the GSC, which have subsequently reported back to the full Council. Some discussion of the results of these investigations and the recommendations made by the Council occurred this academic year at various levels of the MIT administration. This included a presentation and discussion of graduate student concerns regarding tuition, financial aid, and housing at a meeting of the GSC's Executive Committee with the Executive Committee of the Corporation on April 3; a major housing study on the state of graduate on-campus housing; and an Affirmative Action survey of all institute departments admitting graduate students, the results of which will be presented to and discussed with MIT administrators in the near future.

Activities of a social, ethnic, professionally related, or political nature have been steadily increasing within the graduate community as a whole. This is reflected by the increasing number of requests submitted to the GSC's Activities Committee for partial or full funding of scheduled events. While not all activities or groups are deemed appropriate to be sponsored by the GSC, the requests are still there and continue to be addressed.

Interface between the students, the MIT administration, and departments is important to graduate students who often perceive themselves as isolated. The Council is therefore expected to continue to play an important role in the graduate community. The Council is perceived as one of the few places graduate students can go to have their concerns heard or their grievances aired.

Coordination of Women Students' Interests

Emily Weidman, the coordinator for women students' interests, established a weekly Thursday afternoon program in the Cheney Room to bring in speakers and provide a forum for discussion of women's issues. As many as 50 women (and some men) attended such programs as "Women in Science: Two Cultures or One?" and "The Politics of Women's Health." A need for graduate women to get together for their mutual support was also evident. Accordingly, the coordinator initiated meetings of women in Biology, Nutrition and Food Science, and Chemistry. These gatherings provided visibility for the coordinator, and as a result students now seek information and help from her in larger numbers.

The Advisory Committee for Women Students' Interests, chaired by Professor Mildred Dresselhaus, was established this past year to advise the coordinator and serve as a sounding board for her ideas, as well as address issues of concern to women students. This Committee, and many other interested individuals and groups within the MIT community, have been quite helpful to Ms. Weidman in the formulation of specific areas of responsibilities and programs.

ROBERT J. HOLDEN
ANNE GWINNETT PRINCE
EMILY A. WEIDMAN

RESIDENCE PROGRAMS

Institute Houses

The past year began with excessive crowding again in the undergraduate Houses. The figure of 223 crowded rooms was almost double that of any recent year. McCormick Hall was oversubscribed as a result of a larger than anticipated number of freshman women seeking single-sex housing. Again, we were unable to offer housing to college transfer and readmitted students.

In order to move toward full implementation of the Institute's undergraduate housing policy (i.e., the accommodation of all college transfer students, readmitted students, freshmen, and upperclass residents desiring on-campus housing) and to uncrowd the current Houses, a new 352-bed residence at the far west end of campus ("500 Memorial Drive") is being constructed. Even before its scheduled opening in September 1981, it is clear that these additional beds will not be sufficient if we are to implement the existing housing policy. Unless we permanently drop the freshman class size to approximately 1,000, or modify the housing policy, it will be
necessary eventually to build additional housing. A gradual decrease from 1,075 in 1980-81 to 1,000 over the next five years would reduce the undergraduate enrollment to approximately 4,000 by 1985. The need for such a reduction is caused by the increasing percentages of juniors and seniors returning to the dormitory system because they are unable to locate and/or afford off-campus housing and by a desire to offer housing to transfer and readmitted students.

In an effort to meet the needs of women students seeking increased opportunities for single-sex housing, we have planned for a women's single-sex area (as well as a co-ed floor) in 500 Memorial Drive. We have also approved a second all-female floor in Random Hall for next year.

The infirmary building at 350 Memorial Drive is scheduled to become available for housing in the fall of 1981 when the health services department moves to the new medical building on the east side of campus. A decision has been made, subject to available funding, to renovate this facility for use as a residence for approximately 50 graduate women students by the fall of 1982. Since we currently house only 22 percent of the graduate women on campus, as opposed to about 30 percent of the graduate men, this additional residence will meet a critical need.

In making these and many other housing-related decisions, we have benefitted from the advice of the Committee on Student Affairs (CSA), chaired by Professor Arthur C. Smith, and the Committee on Women Students' Interests, chaired by Professor Mildred S. Dresselhaus. An all-day meeting with the CSA at Endicott House was very helpful as a forum to discuss and review housing policies for both undergraduate and graduate students. The Committee also has been supportive in the development of housing projections and recommendations on freshman class size.

Summary housing statistics for the fall term for undergraduate and graduate students follow this report.

Long-range Planning for Housing Needs

This past year, the Dean for Student Affairs was asked by the President to assume senior-level responsibility for the long-range planning of on- and off-campus housing. She has coordinated the efforts of a group of administrators (Administrative Housing Group) who met weekly to discuss and plan for future housing development and expansion of services. An accompanying change occurred in ODSA with the upgrading of a previous half-time Assistant Dean's position in the Residence Programs Section to a full-time position, to allow for increased emphasis on long-range planning as well as residence program development and services for graduate students.

Two extensive surveys also have been conducted this past year within the graduate community and the faculty and staff. One concerning housing and transportation was conducted by the Administrative Housing Group and the other concerning food services was administered by Housing and Food Services. The opinions and demographic data generated from these surveys are expected to provide a wealth of information for long-range planning in these important areas.

An extensive review of the current and possible future uses of Walker Memorial was initiated. We hope that one outcome of this study will be a satisfactory solution to the dining needs of undergraduates in Senior House and East Campus.

Graduate Students

There has been a significant increase over the past year in the contact the Residence Programs Section has had with graduate students. Regular meetings with the Graduate Student Council's Housing and Community Affairs Committee have been held to review on-campus graduate housing policies as well as to discuss other creative solutions to the critical housing shortage existing for graduate students. In addition, several meetings have been held with residents and elected officers of the graduate houses (Ashdown, Tang, Eastgate, and Westgate) in an effort to assess their needs and desires for community-oriented program development.
Faculty and Graduate Residents

The faculty and graduate residents program continues to be the single most important aspect of our overall residence program. Faculty and graduate students participating in the program provide important support to students from a number of different perspectives -- educational, counseling, advising, social, and personal. In-service training programs for new and continuing staff have been expanded and modified, using feedback from participants in earlier programs. During this past year, a graduate resident evaluation form was developed that is to be completed by the floor residents at least once per year. This form, which was devised at the initiative, and with the assistance, of the graduate residents, is designed to provide constructive feedback to the tutors and to give guidance to us regarding the continuation of appointments.

Contact with the faculty in the foreign language section of the Department of Humanities was increased this past year in an effort to improve the recruiting, interviewing, hiring, and evaluation of language house tutors.

Several changes among the faculty residents occurred during the past year. Professor and Mrs. William Thilly announced their "retirement" as junior faculty residents in MacGregor House after several years. Also Professor and Mrs. William Porter decided to reverse their earlier decision to accept an appointment as faculty residents at 500 Memorial Drive.

We are very pleased to report the following new faculty and junior faculty appointments for the 1981-82 academic year:

**Faculty Residents**

| 500 Memorial Drive | Professor and Mrs. Bora Mikic  
| Professor Mikic is a member of the Mechanical Engineering Department. The Mikics have served as Faculty Residents in Senior House for the past four years. |

| Senior House | Professor and Mrs. Samuel Jay Keyser  
| Professor Keyser also serves as Department Head of Linguistics and Philosophy and Director of the Center for Cognitive Science. |

**Junior Faculty Residents**

| MacGregor House | Professor and Mrs. Derek Rowell  
| Dr. Rowell is Associate Professor of Mechanical Engineering. |

| Burton House | Professor Michael A. Marletta and Ms. Jennifer Brunn  
| Dr. Marletta is Assistant Professor of Nutrition and Food Science and the first Mitsui Career Development Professor of Contemporary Technology. |

| West Campus Houses | Professor and Mrs. Jeffrey H. Lang  
| The Langs served as graduate residents in the houses for seven years; Dr. Lang was recently appointed Assistant Professor of Electrical Engineering and Computer Science. |
Dining and Residence Programs

This past year was our first under the new dining plan. As could be expected, there were some problems; however, on balance, the ODSA and the Housing and Food Services (HFS) consider this year's efforts successful. Emphasis was placed throughout the year on a) improving communication between residents and HFS staff primarily through reactivated House Commons Committees; b) improving the cooking and storage facilities in the "cooking Houses"; c) increasing programming in all living groups, including fraternities, with a special effort to bring faculty and staff in closer contact with students in their residences; d) developing a center where women students, faculty, and staff could meet with the reopening of the McCormick Dining Room; e) providing support to the Kosher Kitchen, both short and long range; f) offering nutrition workshops and a "Women and Health" series; and g) providing financial support for bus service for students living in "cooking dorms" to shop at such places as Stop and Shop, Haymarket Square, and the Cambridge Food Co-op. The program coordinator for Dining and Residence Programs, Anita Walton, and the Dining Advisory Board were heavily involved in these and other dining-related activities.

Fraternities and Independent Living Groups

Physical Plant inventories and energy audits of each Independent Residence were completed and reports sent to each of the respective alumni corporations and undergraduate chapters. Several improvements within the system are directly attributable to these reports. For example, 10 Houses are now in various stages of renovation. Following a letter from our office reflecting concern about Houses without sprinklers, five Houses have now completed installations and two plan installations this summer. This will leave only two Houses with partial systems and one with no sprinkler protection at all.

Loans were extended to these Houses by the Independent Residence Development Fund (IRDF) Board of Allocation for the renovations and sprinkler installations described above. In addition, the IRDF funded the refinancing of the Pi Kappa Alpha mortgage and the major renovation at 233 Massachusetts Avenue for the Zeta Psi Chapter House.

Current funds available in the IRDF were insufficient to cover requests for funding, and hence a major fund drive for the IRDF is being planned for the 1981-82 academic year under the chairmanship of Stephen Stuntz (Sigma Phi Epsilon, Class of 1967).

We continue to appreciate and recognize the important contribution the Treasurer's staff has made in ensuring the viability of the Independent Residence System.

At the end of the year, vacancies on the Steering Committee of the Alumni Interfraternity Conference (AIFC) increased to five following the resignation of Merrick Leler (Lambda Chi Alpha, Class of 1974) and the retirement of John Danforth (Delta Psi, Class of 1940). Dan Holland (Delta Tau Delta, Class of 1958) completed his sixth year as AIFC chairman and will be stepping down to be succeeded by Russell Cox (SAE, Class of 1949).

Other developments within the system this year included holding IFC budget hearings for the first time, a reduction in the number of de-pledgings, and the re-emergence of the IFC newsletter InFocus as a means of increasing communication throughout the system.

Discipline

A number of discipline cases involving living groups were adjudicated by the Associate Dean in charge of Residence Programs. One student was suspended from his residence, four others were declared persona non grata in certain Houses, two were put on Dean's Office Probation and five were given a Dean's Office Warning for various offenses such as theft, harassment, illegal phone calls, and possession of drugs. Three living groups were also given Dean's Office Warnings for theft of furniture and the harassment of other living groups. One fraternity was put on Dean's Office Probation for irresponsible actions during its initiation period.
Vice President in the Office of the President

Committees

Members of the Residence Programs staff served on the following committees: the Administrative Council, Administrative Housing Group, Dining Advisory Board, AIFC, IRDF, Safety Committee, 500 Memorial Drive Client Team, 350 Memorial Drive Client Team, Walker Memorial Client Team, and the Zeta Psi Client Team.

Staff Changes

Dr. Peter H. Brown joined the Residence staff as Assistant Dean for Student Affairs in March, replacing Dean Robert M. Randolph who was promoted to Associate Dean for Student Affairs and Head of the Student Assistance Services Section.

ROBERT A. SHERWOOD
PETER H. BROWN
STEPHEN D. IMMERMAN
ANITA T. WALTON

RESIDENTIAL DISTRIBUTION OF MIT STUDENTS

Fall Term 1980-81

Regular Graduate Students

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<th>MIT HOUSING</th>
<th>Men</th>
<th>Women</th>
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<td>Ashdown</td>
<td>322</td>
<td>65</td>
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<tr>
<td>Tang</td>
<td>354</td>
<td>50</td>
<td>404</td>
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<td>Graduate Residents (Single)</td>
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<td>Total Single Graduates -- On Campus</td>
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<td>128 (17.3%)</td>
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<td>Eastgate</td>
<td>171</td>
<td>26</td>
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<tr>
<td>Westgate</td>
<td>200</td>
<td>9</td>
<td>209</td>
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<tr>
<td>Graduate Residents (Married)</td>
<td>22</td>
<td>4*</td>
<td>26</td>
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<tr>
<td>Total Married Graduates -- On Campus</td>
<td>393 (11.1%)</td>
<td>39 (5.3%)</td>
<td>432 (10.1%)</td>
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<tr>
<td>Total Graduates -- On Campus</td>
<td>1,003 (30.8%)</td>
<td>167 (22.6%)</td>
<td>1,260 (29.4%)</td>
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<td>OFF CAMPUS</td>
<td>2,454 (69.2%)</td>
<td>574 (77.4%)</td>
<td>3,028 (70.6%)</td>
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<td>TOTAL REGULAR GRADUATES</td>
<td>3,547 (100%)</td>
<td>741 (100%)</td>
<td>4,288 (100%)</td>
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*In four couples, both members are students.
### INSTITUTE UNDERGRADUATE HOUSE COUNT

#### 1980–81

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<th></th>
<th>1 M</th>
<th>1 F</th>
<th>2 M</th>
<th>2 F</th>
<th>3 M</th>
<th>3 F</th>
<th>4 M</th>
<th>4 F</th>
<th>Other M</th>
<th>Other F</th>
<th>Total M</th>
<th>Total F</th>
<th>TOTAL</th>
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<td>221</td>
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<td>1,844</td>
<td>664</td>
<td>2,508</td>
<td>2,285</td>
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Dean for Student Affairs
Department of Athletics

In my first year as director of Athletics at MIT, I want to make particular mention of the extraordinary contributions of my predecessor, Professor Ross "Jim" Smith, and to thank him for his effective leadership during the transition. I am equally thankful for the guidance, flexibility, and competence exhibited by our full-time and part-time staff as they adjusted to a new director. Finally, I want to express my continuing pleasure with the opportunity of serving MIT as the new director of Athletics.

This report will present for permanent record a broad statistical review of the wide-ranging intercollegiate, club varsity, intramural, physical education, recreational, and special activities conducted and managed for MIT undergraduate and graduate students, faculty, staff, and general community.

GENERAL OVERVIEW

During the academic year 1980-81, student participation increased in virtually all student programs of the Department of Athletics (see Table I) with the exception of women's intercollegiates, which registered a slight decline in total participation and letter award winners. However, our women's intercollegiate program continues to be one of the broadest in the country with 10 varsity programs (increasing to 11 in 1981-82 with the addition of cross country) and a total participation of more than 25 percent of enrolled undergraduate women, as compared to 17 percent intercollegiate participation for men in 21 varsity programs.

Physical Education, intramural, and club sport participations are all higher than last year, due primarily to the new Special Events and Athletic Center. The Athletic Center allowed the Physical Education Department to add the popular programs of skating and ice hockey to its curriculum. MIT's club sports added the two successful programs of ultimate frisbee and women's ice hockey (total 25 club programs) while increasing student club sport participations to 589, a 25 percent increase over last year. The MIT Intramural Program once again enjoyed the greatest participation of any single division within our Department, with 28 program offerings and 12,067 cumulative student participations from an estimated two-thirds of our undergraduate men and women plus a significant number of graduate students.

PHYSICAL EDUCATION

The objective of the Physical Education Program at MIT is to complement the academic program and enrich the human environment by encouraging and developing recreational interests and lifetime participation habits regardless of skill level. To accomplish this, we intend to offer a wide variety of activities in relatively small classes with trained, high-quality coach and staff instructors sensitive to individual participant needs and potential. We are pleased to note the 6,134 physical education registrations this past year reversed a three-year decline in total registrations, but we continue to develop plans to improve the quality of our physical education procedures, programs, and instruction. The following steps have been taken as part of our effort to undergird the excellence of our Physical Education Department.

1) The Department has established a permanent internal Physical Education Committee under the chairmanship of Professor Ed Crocker to review, examine, and self-evaluate physical education matters of procedures, curriculum development, teaching responsibilities, and instructor training.
Department of Athletics

2) The Physical Education Committee has had approved a recommendation to relieve in-season head coaches from four hours of weekly teaching assignments. They will thus carry eight hours in season rather than 12. This action was taken to provide responsible assignment equity and to reduce the possibility of overburdening instructors to the detriment of the quality of our physical education instruction.

3) This coming year we will initiate a series of in-service training programs to upgrade and expand our instructors' teaching skills. The training programs are planned for Friday mornings, and will be monitored on a trial basis to evaluate effectiveness.

4) An Athletic Department/Registrar's Office working committee (comprised of Fran O'Brien from Athletics and Ron Smith of the Registrar's Office) was established to develop jointly a set of common procedures that will eliminate the annual pre-graduation crisis of seniors who have not fulfilled the physical education requirement.

During the first half of the coming academic year 1981-82, Professor and Director of Physical Education Ed Crocker will be on sabbatical leave. The acting co-directors through February 1982 will be Professors Fran O'Brien and Gordon Kelly.

CLUB ATHLETICS

Under the effective leadership of Professor Jack Barry, club coordinator, the club activities continue to grow and to fulfill a special community need through increased opportunities in athletics and recreation for graduate students and special undergraduate groups (see Table II). While all segments of the community take part, the club program is unique in its aim at graduate student participation.

Added financial support over the past year, while not large, has encouraged growth and strengthened existing club activities. A club handbook, covering club activities, is made available to all new students.

Some high points in club programs are listed below.

1) MIT Football Club had a 6-1 record and was invited to the national playoffs. MIT student participants totaled 47 (including five graduate students).

2) New Women's Ice Hockey Club in its first year grew stronger and finished the season by playing three games. There were 24 participants.

3) MIT's Rugby Team placed three players on the All New England side.

4) The Figure Skating Club put on an ice show in the new indoor rink which was well received by the community.

5) The Grad Soccer Club had another successful year in the Massachusetts Soccer Association, but lost in the championship finals.

The following steps are being taken to improve the environment for club programs.

1) We have increased financial support to selected programs where justified by student interest and needs.

2) The expanded Club Handbook will cover the entire spectrum of activities and should encourage more student interest.

3) We are strengthening the lines of communication between the Athletic Board and the Graduate Student Council through the leadership of graduate student and Athletic Board member Harrison Weed.

4) Club Football has joined the New England Collegiate Club Football League (members include Providence and Assumption colleges, University of Hartford, Roger Williams, Fitchburg State, Worcester State, and Bentley colleges, and MIT). This league provides equitable competition, continuity of schedule, and reduced travel demands and costs.
5) Bowling has been approved by the MITAA Executive Council as the 26th club program for 1981-82. We expect close to 20 student participants.

INTERCOLLEGIATE ATHLETICS

Intercollegiate athletics at MIT provide our students with the opportunity to develop to the fullest their competitive instincts and athletic skills in a non-professional atmosphere, with outstanding coaches and superior facilities.

Intercollegiate recreation and competition for men and women is offered in 31 athletic programs (see Table III) with participation this past year totaling 856 undergraduate men and women (19 percent of the total undergraduate enrollment -- 26 percent of that figure are women students and 17 percent are men).

The intercollegiate teams enjoyed sufficient success in terms of wins and losses to provide a modicum of competitive satisfaction for students and coaches alike. The MIT men enjoyed the first overall winning record in several years (also see Table III) with a .519 winning percentage in the 19 sports where competitive record-keeping is feasible (sailing and skiing only compete in meets or tournaments). The MIT women had a respectable competitive record with a .405 winning percentage as compared to last year's winning percentage of .452.

Championships -- Notes of Interest

During the fall, MIT hosted both the Greater Boston Championships (Oberg Trophy) and Dinghy Championships (Schell Trophy) in men's sailing. During the winter, MIT hosted two gymnastics championships: the New England Invitational for men and the Massachusetts AIAW championships for women. MIT also hosted the National Collegiate and Intersectional pistol championships, and the National Rifle Association Collegiate Air Rifle and Smallbore sectional. MIT hosted the Greater Boston Conference swimming championships (which attracted coverage from all three major TV stations in Boston). During the spring, we hosted the Boston Dinghy Club Cup sailing regatta, a major event which featured the nation's top sailing teams. In addition, MIT was the site for several other meets hosted by high schools and other groups.

The following steps have been set in motion for 1981-82 to further enhance the high quality of MIT's Intercollegiate Athletic Program.

1) Women's cross country will be the eleventh varsity intercollegiate sport for women, effective in the fall of 1981. A part-time coach has been hired, and we expect this program to increase women's intercollegiate participation. This is MIT's first intercollegiate track offering for women.

2) MIT's first coordinator of sports medicine was hired in June to manage our athletic training program and to improve health care services for athletic-related injuries.

3) The first woman head coach of women's tennis was hired, effective in September 1981. Candace Royer, head coach of women's tennis at Penn State for the last four years, brings excellent experience in physical education teaching as well as coaching. We expect Professor Royer to enhance our women's squash program in future years.

4) This summer night lights for the Briggs Field Area A will be installed. These lights will relieve the severe intercollegiate practice problem.

Men's Intercollegiate Honors

- With a 12-11 record, the basketball team enjoyed its second consecutive winning season for the first time since 1972.

- The cross country team competed in the NCAA Division III championships for the second consecutive year and posted a 4-3 record in dual-meet competition for its third straight winning season.
The fencing team posted a fine 11-3 record, placed fourth in the Intercollegiate Fencing Association meet and ninth in the NCAA Championships. The Engineers enjoyed their twelfth straight winning season with an outstanding 131-34 record over that stretch.

The golf team was 10-6 this past spring for its fifth consecutive winning season (48-20 over that span).

The highly regarded lacrosse team enjoyed its third consecutive winning season with a 7-6 record in 1981.

The pistol team (5-2) captured the Intercollegiate Sectionals.

The rifle squad posted a 20-4 record for its seventh straight winning season, won both the Collegiate Air Rifle and Smallbore sectional titles, and captured the team title in the New England College League.

The men's sailing team hosted and won the fall Dinghy Championships (Schell Trophy), captured the Wood Trophy at Brown University, and placed second in the highly regarded Boston Dinghy Club Cup and fourth in the prestigious Atlantic Coast Championships at Navy, and finished in the top five in 21 of 33 regattas.

The indoor (8-2) and outdoor (4-1) track squads combined for an outstanding 12-3 record with both teams winning New England Division III championships -- the first time a New England school has won both titles in the same season. The outdoor team also scored over 100 points on three different occasions in 1981.

**Women's Intercollegiate Honors**

- Karen Klincewicz, Class of 1982, earned All-America recognition in both the 100- and 200-yard butterfly events at the AIAW Division III swimming championships held in Cedar Rapids, Iowa.

- Julia Neuringer, Class of 1981, was the recipient of the Betsy Schumacker Award. Ms. Neuringer capped a brilliant four-year career on the field hockey team by leading the team in scoring with 16 goals. Ms. Neuringer was the subject of a feature article in the national publication, *Women's Varsity Sports*.

**Other Noteworthy Events**

- On September 23, 1980, the women's crew team received the Catharine McCurdy shell ("The Kate"), donated by H.W. "Mac" McCurdy, Class of 1922 and captain of the first varsity team at MIT; and the men's lightweight squad received the Admiral Edward L. Cochrane shell donated by Captain and Mrs. Edward L. Cochrane, Jr., Class of 1920.

- On April 24, 1981, the Ross "Jim" Smith shell was christened for the men's heavyweight team in honor of Jim Smith, director of athletics from 1960-80 and honorary alumnus, who retired in 1980. The shell was donated by Mac McCurdy in Jim's name.

**INTRAMURAL ATHLETICS**

As former Athletic Director Professor Jim Smith said in last year's annual report, intramural athletics (IM) have the largest student participation of any Athletic Department program (all activities are coed), and represent the lifeblood of our program. In 1980-81 there were 28 different IM programs (compared to 26 last year) with 12,067 cumulative student participations (compared to 11,200 last year). In actual numbers of students, we estimate that over 60 percent of the total undergraduate enrollment is involved in at least one of our 28 current IM activities.

In the coming year, we plan to devote considerable effort to identifying and improving support from the Athletic Department for our important and valued Intramural Program. This
spring, IM Director Professor Dave Michael and three IM student leaders attended a four-day national IM conference in Philadelphia sponsored by the National Intramural and Sports Recreation Association. As a result of the conference, several broad student–Athletic Department joint objectives have been established for improving and strengthening IM communications, supervision, problem solving, statistical record keeping, planning, and general Athletic Department administrative support.

As a direct result of the Philadelphia conference, the IM Handbook has been rewritten and clarified to simplify student understanding and procedures. Other specific plans to accomplish the broader improvement objectives will be developed in the fall by Professor Michael and the IM Student Executive Committee.

COMMUNITY RELATIONS

Recreation and Instruction for Students and the MIT Community

Diversified programs are offered throughout the year to children of members of the MIT community. These include ice skating and swimming instruction and an eight-week summer day camp. Adult instructional programs are offered as a service to the community in the following areas: cardiopulmonary resuscitation, self-designed fitness, golf, sailing, sculling, tennis, and dance.

All athletic facilities are open for use by members of the community on a reservation basis. The hours of the Har-Tru surfaced tennis courts were expanded this spring. Preparation is being made to similarly expand open hours at Alumni Swimming Pool.

The Community Softball Program operates in the summer months and includes approximately 75 teams.

Athletic Card Usage

Athletic and sailing card sales and usage increased in 1980–81 indicating increased use of our athletic facilities and the high level of program participation by the MIT community.

<table>
<thead>
<tr>
<th></th>
<th>1979–80</th>
<th>1980–81</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Athletic Card Sales</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students</td>
<td>6,574</td>
<td>7,024</td>
<td>(+ 450)</td>
</tr>
<tr>
<td>Faculty</td>
<td>332</td>
<td>331</td>
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<tr>
<td>Staff</td>
<td>1,664</td>
<td>1,721</td>
<td></td>
</tr>
<tr>
<td>Family</td>
<td>379</td>
<td>438</td>
<td></td>
</tr>
<tr>
<td>Alumni</td>
<td>367</td>
<td>354</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>9,316</td>
<td>9,868</td>
<td>(+ 552)</td>
</tr>
</tbody>
</table>

|                  |         |         |        |
| **Sailing Card Sales** |       |         |        |
| Student          | 846     | 1,442   | (+ 596) |
| Faculty/Staff    | 201     | 217     |         |
| Alumni           | 82      | 91      |         |
| Special Family   | 279     | 166     |         |
| **TOTAL**        | 1,408   | 1,916   | (+ 508) |
Boston/Cambridge Community Relations

The Institute has long maintained the philosophy of interaction with the Cambridge and Boston communities by making available facilities for use by community groups.

Every effort is made to schedule these neighborhood groups in such a way that they do not interfere with MIT community use of the same facilities. Emphasis is placed on offering our facilities to youth groups, underprivileged groups, minority groups, and all those which the local community finds difficult to accommodate, either due to their own lack of resources or because of a temporary unavailability of these resources.

For example, the Cambridge Rindge and Latin High School gym was being renovated last winter, and the MIT Athletic Department was able to accommodate many of the school's physical education classes. The Cambridge school system also uses field space during the spring and fall for physical education classes. The Department encourages MIT student groups that work with community youth, for example, the APO, NCAA Volunteers for Youth, and SAE Muscular Dystrophy Fund Raiser.

The Cambridge Police Department regularly uses the MIT Pistol Range, and also holds their basketball league games weekly in duPont Gym.

MIT ATHLETIC FACILITIES

The Special Events and Athletic Center was opened in the fall of 1980. This facility expanded opportunities for all aspects of the Athletic program: intercollegiate, intramural, physical education, and recreation. The specific activity areas within the facility include: an ice rink, 200-meter track, four basketball courts, and four tennis courts.

Rockwell Cage was improved by installing a multi-use synthetic floor surface. The surface now accommodates a varsity basketball game court, six high-quality volleyball courts, three and a half basketball courts, and 10 badminton courts.

Funding for a new maple floor for the duPont Gymnasium was approved, and construction began in late June. This renovation will permit a permanent equipment site for men's and women's gymnastics, as well as enhance activities in the gym.

STAFF ACCOMPLISHMENTS

Walt Alessi served as president of the New England Intercollegiate Lacrosse Association.

John Benedick was selected the 1981 New England swimming coach of the year.

Jane Betts, assistant director of Athletics, served as Division III vice president of the Association of Intercollegiate Athletics for Women (AIAW) during 1980-81.

Ken Cerino, sports information director, served as publicity director for the Greater Boston Conference during 1980-81, and was named first vice president of the Eastern College Athletic Conference Sports Information Directors (ECAC-SID) for 1981-82.

Doug Clark was selected by the US Women's Olympic Committee as an assistant coach for the women's national team.

Ed Crocker, director of physical education, completed his 25th year as men's tennis and squash coach.
Royce N. Flippin, Jr., director of Athletics, served as president of the Greater Boston Conference during 1980-81.

Paul Grace, former head trainer at North Adams State College, was named to the new position of coordinator of Sports Medicine at MIT.

Gordon Kelly served as president of the New England Track Coaches Association.

John Murphy, equipment supervisor, completed his thirty-third year as a member of the Athletic staff.

Staff Changes

New Appointments (effective 1981-82):
Paul Grace, coordinator of Sports Medicine.

Thomas Howes, freshman coach of heavyweight crew, part-time.

Christopher Lane, head coach of women's cross country, part-time.

William Malone, assistant manager of athletic facilities.

Candace Royer, assistant professor in physical education, head coach women's tennis.

James Taylor, acting head coach men's tennis and squash, part-time (replacing Ed Crocker on sabbatical).

Resignations
Mark Ayotte, trainer, part-time, to Iona College in full-time position.

John Miller, freshman coach of heavyweight crew, part-time, to private business.

Jon Mooar, head coach of rifle, part-time, to private business.

Manuel Weiss, assistant professor of physical education and head coach women's tennis, to enter business.

On Leave:
Deborah Clum, instructor of physical education and head coach of field hockey and softball, fourth quarter 1981.


ROYCE N. FLIPPIN, JR.
TABLE I

MIT ATHLETIC PROGRAM PARTICIPATION

<table>
<thead>
<tr>
<th>STUDENT ENROLLMENT</th>
<th>1979-80</th>
<th>1980-81</th>
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<tbody>
<tr>
<td>(October Figures -- includes Specials) Undergraduate Women</td>
<td>806</td>
<td>891</td>
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<tr>
<td>Undergraduate Men</td>
<td>3,711</td>
<td>3,686</td>
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<tr>
<td>TOTAL</td>
<td>4,517</td>
<td>4,577</td>
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<tr>
<td>Graduate Women</td>
<td>759</td>
<td>846</td>
</tr>
<tr>
<td>Graduate Men</td>
<td>3,817</td>
<td>3,942</td>
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<tr>
<td>TOTAL</td>
<td>4,576</td>
<td>4,788</td>
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<tr>
<td>GRAND TOTAL STUDENTS</td>
<td>9,093</td>
<td>9,365</td>
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<table>
<thead>
<tr>
<th>STUDENT PARTICIPATIONS (Includes Multiple-Activity Duplication)</th>
<th>1979-80</th>
<th>1980-81</th>
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</thead>
<tbody>
<tr>
<td>PHYSICAL EDUCATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programs</td>
<td>36</td>
<td>38</td>
</tr>
<tr>
<td>Total Registrations</td>
<td>5,861</td>
<td>6,134</td>
</tr>
<tr>
<td>(Undergraduate)</td>
<td>(5,030)</td>
<td>(5,156)</td>
</tr>
<tr>
<td>(Graduate)</td>
<td>(578)</td>
<td>(708)</td>
</tr>
<tr>
<td>(Staff)</td>
<td>(253)</td>
<td>(270)</td>
</tr>
<tr>
<td>INTRAMURALS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programs</td>
<td>26</td>
<td>28</td>
</tr>
<tr>
<td>Teams</td>
<td>1,195</td>
<td>1,289</td>
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<tr>
<td>Students</td>
<td>11,200</td>
<td>12,067</td>
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<tr>
<td>CLUBS</td>
<td></td>
<td></td>
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<tr>
<td>Programs</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>Students</td>
<td>466</td>
<td>589</td>
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<tr>
<td>INTERCOLLEGIATES</td>
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<td></td>
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<tr>
<td>Women's Programs</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>- Students</td>
<td>244</td>
<td>233</td>
</tr>
<tr>
<td>- Letter Awards</td>
<td>174</td>
<td>145</td>
</tr>
<tr>
<td>(Varsity)</td>
<td>(98)</td>
<td>(94)</td>
</tr>
<tr>
<td>(Junior Varsity)</td>
<td>(64)</td>
<td>(31)</td>
</tr>
<tr>
<td>(Frosh)</td>
<td>(12)</td>
<td>(20)</td>
</tr>
<tr>
<td>Men's Programs</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>- Students</td>
<td>600</td>
<td>623</td>
</tr>
<tr>
<td>- Letter Awards</td>
<td>454</td>
<td>475</td>
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<tr>
<td>(Varsity)</td>
<td>(351)</td>
<td>(259)</td>
</tr>
<tr>
<td>(Junior Varsity)</td>
<td>(163)</td>
<td>(142)</td>
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<tr>
<td>(Frosh)</td>
<td>(40)</td>
<td>(74)</td>
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<tr>
<td>CLUB PROGRAMS</td>
<td>Participants</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>--------------</td>
<td></td>
</tr>
<tr>
<td>Archery</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Badminton</td>
<td>16</td>
<td></td>
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<tr>
<td>Cheerleading</td>
<td>12</td>
<td></td>
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<tr>
<td>Cricket</td>
<td>23</td>
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<tr>
<td>Fencing</td>
<td>24</td>
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<tr>
<td>Figure Skating</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Football</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>Folk Dance</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>*Frisbee</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Hockey, Men</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>*Hockey, Women</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Judo</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Karate, Shotokan</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Rifle and Pistol</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Rugby, Men</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Rugby, Women</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Scuba</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>*Society for Creative Anachronism</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Soccer, Graduate</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Square Dance</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Table Tennis</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Tae Kwon-Do</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Volleyball, Men</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Water Polo, Women</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>White Water</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL PARTICIPANTS** 589 in 25 Programs

*New Clubs 1980-81
TABLE III
MIT VARSITY COMPETITIVE RECORDS IN INTERCOLLEGIATE ATHLETIC COMPETITION 1980-81

<table>
<thead>
<tr>
<th>MEN'S SPORTS (19 Sports Listed)</th>
<th>WOMEN'S SPORTS (9 Sports Listed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Won</td>
<td>Lost</td>
</tr>
<tr>
<td>-----</td>
<td>------</td>
</tr>
<tr>
<td>Fall</td>
<td>Cross Country</td>
</tr>
<tr>
<td></td>
<td>Soccer</td>
</tr>
<tr>
<td></td>
<td>Water Polo</td>
</tr>
<tr>
<td>Winter</td>
<td>Basketball</td>
</tr>
<tr>
<td></td>
<td>Fencing</td>
</tr>
<tr>
<td></td>
<td>Gymnastics</td>
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<tr>
<td></td>
<td>Pistol</td>
</tr>
<tr>
<td></td>
<td>Rifle</td>
</tr>
<tr>
<td></td>
<td>Squash</td>
</tr>
<tr>
<td></td>
<td>Swimming</td>
</tr>
<tr>
<td></td>
<td>Track, Indoor</td>
</tr>
<tr>
<td></td>
<td>Wrestling</td>
</tr>
</tbody>
</table>

| TOTALS 1980-81 | 125 | 116 (.519) | TOTALS 1980-81 | 53 | 77 | 1 (.405) |
|               | 1979-80 | 118 | 119 (.494) | 1979-80 | 52 | 61 | 2 (.452) |

(1) No won-lost record for Sailing and Skiing
(2) No won-lost record for Sailing
Office of Admissions

The well-heralded demographic changes of the next two decades have yet to impact on college enrollments, but the admissions officers and academic planners are taking steps to position themselves for the anticipated shrinkage in the cohort of high school students. Marketing skills are being sharpened, budgets are being adjusted, and some college publications are being transformed to look like travel brochures. The competition is slowly changing from one in which students struggle to "get in," to one where colleges vie for students. There are still colleges where students compete for places, but the number is a small fraction of the total and will be getting smaller. This all brings to the admissions process new tensions and the need for rethinking what it is we set out to accomplish and how we intend to deal with these new realities.

For years MIT has been blessed with an abundance of talented applicants who want to join the MIT community. Most who aspire to enroll here have taken the required four years of English, four years of mathematics, and science (physics and chemistry). Our applicants discovered their interest in math/science early on and developed that interest, while many of their classmates avoided the opportunity to build a math and science literacy. The coming years demand citizens whose education prepares them to deal with technological aspects of the issues that are so much a part of our political and economic life. Be the topic hazardous waste, nuclear power, water supplies, or medical care, the mathematics to understand the data relating to these issues must be a part of the informed citizen's knowledge. We at MIT must speak to the issue of the citizen's education in general as well as to what we expect for our students. The opportunity and responsibility to speak out on secondary education is ours.

We begin our admissions year in April by preparing mailings to send to students whose names have been given to us by the College Board on the basis of their performance on the Preliminary Scholastic Aptitude Test. These "search" mailings go to men, women, and minorities, totaling over 25,000 potential applicants. These same people are invited to meet our staff as they travel across the country in the fall. In addition, we attend the National Scholarship Service and Fund for Negro Students (NSSFNS) meetings in major cities. NSSFNS directs its attention primarily to black students, but includes other minorities. These efforts, including meetings with alumni, telephone campaigns, and letters authored by students, are the ways in which we seek to encourage students to consider applying to MIT. This past spring we have made a particular effort to increase the numbers of blacks and women on the Educational Council, for they will be able to make a major contribution as role models. All this must happen before we settle down for a winter's reading of folders and selection meetings.

Considerable progress has been made with our data management system, and we expect, by the end of next year, to have graduate, undergraduate, college transfer, and special applications processed by this new tool.

The Educational Council members under Bonny Kellermann's leadership continue to represent MIT to the secondary schools in their home communities. This year, nine of the Educational Counselors received the George B. Morgan Award in recognition of sustained excellence in their work for the Council. The recipients for 1980 are Philip Dressigacker, Jr., '37; Bernard Edelman, '53; Alan MacLean, '44; Francis O. Merchant, '33; Thomas E. Pawel, '48; Arthur J. Power, '42; Arthur Schwartz, '47; David Steelman, '64; and E. Hibbard Summersgill, '36.
### ADMISSIONS TRENDS 1975-81

<table>
<thead>
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<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary applications</td>
<td>8,166</td>
<td>8,104</td>
<td>7,853</td>
<td>9,320</td>
<td>10,274</td>
<td>11,223</td>
<td>12,526</td>
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<tr>
<td>Final applications</td>
<td>4,726</td>
<td>5,194</td>
<td>4,838</td>
<td>4,870</td>
<td>5,368</td>
<td>5,677</td>
<td>5,922</td>
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<tr>
<td>Admissions offered</td>
<td>2,106</td>
<td>2,277</td>
<td>1,939</td>
<td>1,865</td>
<td>1,813</td>
<td>1,809</td>
<td>1,909</td>
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<tr>
<td>Actual registrations</td>
<td>1,154</td>
<td>1,044</td>
<td>1,073</td>
<td>1,059</td>
<td>1,059</td>
<td>1,081</td>
<td>1,031</td>
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<tr>
<td>Registrations as percent of admissions</td>
<td>54.7%</td>
<td>47%</td>
<td>55.3%</td>
<td>56.7%</td>
<td>58.4%</td>
<td>59.7%</td>
<td>54%</td>
</tr>
<tr>
<td>Number of secondary schools represented</td>
<td>918</td>
<td>866</td>
<td>859</td>
<td>877</td>
<td>893</td>
<td>894</td>
<td>835</td>
</tr>
<tr>
<td>Percent of students from northeastern states</td>
<td>50.8%</td>
<td>48%</td>
<td>52%</td>
<td>50.6%</td>
<td>49%</td>
<td>47.8%</td>
<td>51.9%</td>
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### College Transfers

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</thead>
<tbody>
<tr>
<td>Total applications</td>
<td>879</td>
<td>941</td>
<td>1,079</td>
<td>1,074</td>
<td>1,143</td>
<td>1,331</td>
<td>818</td>
</tr>
<tr>
<td>Applications completed</td>
<td>499</td>
<td>536</td>
<td>591</td>
<td>535</td>
<td>486</td>
<td>471</td>
<td>399</td>
</tr>
<tr>
<td>Admissions offered</td>
<td>200</td>
<td>203</td>
<td>175</td>
<td>172</td>
<td>152</td>
<td>167</td>
<td>93</td>
</tr>
<tr>
<td>Actual registrations</td>
<td>155</td>
<td>162</td>
<td>141</td>
<td>123</td>
<td>124</td>
<td>119</td>
<td>76</td>
</tr>
<tr>
<td>Registrations as percent of admissions</td>
<td>77.5%</td>
<td>80%</td>
<td>81%</td>
<td>72%</td>
<td>82%</td>
<td>71%</td>
<td>82%</td>
</tr>
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</table>

### Graduate Students

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<tr>
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</thead>
<tbody>
<tr>
<td>Total applications</td>
<td>6,447</td>
<td>7,511</td>
<td>7,740</td>
<td>7,454</td>
<td>7,849</td>
<td>7,832</td>
<td>9,075</td>
</tr>
<tr>
<td>Admissions offered</td>
<td>2,119</td>
<td>2,676</td>
<td>2,644</td>
<td>2,724</td>
<td>2,636</td>
<td>2,380</td>
<td>2,926</td>
</tr>
<tr>
<td>Actual registrations</td>
<td>1,015</td>
<td>1,441</td>
<td>1,369</td>
<td>1,461</td>
<td>1,362</td>
<td>1,212</td>
<td>1,465</td>
</tr>
<tr>
<td>Registrations as percent of admissions</td>
<td>48%</td>
<td>54%</td>
<td>52%</td>
<td>54%</td>
<td>52%</td>
<td>51%</td>
<td>50%</td>
</tr>
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PETER H. RICHARDSON

### Career Planning and Placement Office

For the third year in a row, demand for the Institute's graduates was exceptionally strong. However, for reasons which are not yet clear, students seemed less interested in talking with employers this year than in 1978-79 or 1979-80. A total of 406 companies and government agencies came to interview students in the Career Planning and Placement Office, compared with 404 in 1979-80 and 409 in 1978-79. There have been only two other times since the Second World War when there have been such sustained spells of recruiting activity, between 1955 and 1958 and again between 1965 and 1968. At the end of the academic year, there were signs that the market might be slackening. There was less demand from the semiconductor industry, some computer companies reduced their hiring, and there was a perceptible hesitation on the part of a number of industries dependent on capital spending. Nevertheless, many firms were asking how they could attract a larger share of MIT talent, and the Office's recruiting facilities are already fully booked for a number of weeks in the coming year. The demand is not easily accounted for by economic indicators. It would be nice to think that firms are more aware of the value of the productive engineer and scientist, and that this is offsetting the negative economic variables. There is some evidence that this is so.

While the demand remained strong, fewer students asked to have their resumés circulated to companies, and fewer signed up for interviews. Approximately 545 students submitted resumés.
Vice President in the Office of the President

for the two-volume resume book (which the Office publishes serially in September and December) compared with 747 the year before. The smaller resume book proved prophetic because the number of students having interviews dropped by a like amount, from 1,741 to 1,417. However, individuals had more interviews so total student interviews (8,330) were close to the previous year's total (8,476). Including interviews by postdoctorals, alumni, and others, the absolute total of interviews was even higher than the previous year, 8,797 in 1980-81 compared with 8,718 in 1979-80.

Fewer students had interviews at each degree level (S.B., S.M., Ph.D). The decline in the number of S.B. and S.M. candidates seeking interviews may be a sign that more students are deciding to continue for a higher degree. In 1979-80 only 44.9 percent of graduating bachelors declared that they were proceeding on to graduate school. If one includes students who were already getting a master's degree with their bachelor's degree, it raises the total to 50.7 percent. The last time either percentage was so low was 20 years ago, in 1959-60, when the nation was beginning a concerted push to increase the number of engineering and science students taking graduate degrees. The proportion of MIT seniors going on for a higher degree rose from 41 percent in 1957-58 -- the year of Sputnik -- to 79 percent in 1965-66. In 1968-69, the year of Apollo, the proportion was down to 56 percent. The highest it has been since it was 64 percent in 1974-75 (68 percent if one includes students getting the master's and bachelor's degrees at the same time). There has been much talk about the need for more young scientists and engineers to obtain advanced degrees, and last year's graduating class may be following this trend. We sent questionnaires to students at graduation, and we will know more about their plans when the questionnaires are returned and tabulated.

MASSACHUSETTS HIGH TECHNOLOGY COUNCIL

The demand for MIT graduates comes from all parts of the country, as well as from New England. In many areas of technology, the most exciting opportunities exist elsewhere rather than in New England. In electronics, however, New England is humming. New England firms offer the attraction of state-of-the-art engineering, a youthful, entrepreneurial style, and a geographic location which many students, in spite of taxes and the cost of living, rate above all others. In recent years a third or more of the graduates in electrical engineering have taken jobs with Massachusetts-based firms. In 1980, 47 percent of the bachelor's degree recipients in electrical engineering who took jobs in industry went to work in Massachusetts, compared with 23 percent in other fields. Nevertheless, many firms elsewhere have a strong appeal, and they work hard to recommend themselves to students. There is a tendency for local firms, just because they are so near, not to plan their recruiting so carefully. Discussions between the director and a representative of the Massachusetts High Technology Council, B.J. Rudman, led to the organizing of a working conference in December 1980 for the benefit of member companies on recruiting the technical graduate. The conference was held at Northeastern University's Henderson House in Weston, and included speakers from five other universities and colleges besides MIT. Ray Stata, president of Analog Devices, Inc., opened the proceedings and stayed for the day. Fifty personnel officers attended from 36 companies. In January the Office joined forces with the Alumni Office in planning a series of student visits to Massachusetts companies during the Independent Activities Period. The Office has been happy to remind students that they can "make it in Massachusetts."

ADVISING AND COUNSELING

The decline in the number of students having interviews was not accompanied by any decline in the number of students or alumni coming for advice and counsel. Judging by the comments of individuals using our services, the Office is valued for its helpfulness. Students and others frequently tell us that we have been recommended by their friends. Students return when they have completed another lap in their education, and alumni call us who used us as students. Our clientele also includes MIT employees who would like to review the career options open to them. During the year, Linda Stantial and Jane Wells collaborated with two members of the
Personnel Office, Pat Williams and Susan Warshauer, in writing a booklet describing how employees can find help at the Institute and in the community with career development. The booklet, entitled Career Assistance for Employees, is now at press.

The Office sets store in being as well informed and informative as possible about the options students may wish to consider. The stress is on discussing these options with students rather than their abstract inclinations. Most students have an idea what they would like to do, though they are sometimes shy about declaring it. In the words of Emily Dickinson,

"Exists in every human nature
A goal,
Admitted scarcely to itself, it may be,
Too fair
For credibility's temerity
To dare."

What students really want to know is how they can achieve their ambition. Many career counselors put their emphasis on clarifying their clients' values and skills, referring them to the library to find out how they can apply them in the working world. In an article, "A Dissenting View of the Career Counselor's Role," which appeared in the June issue of the Journal of College Placement, the director of the Office stressed the importance of the counselor being a fount of information for the student looking for advice.

STAFF

In December, Ms. Wells left the office to work on assignments for Vice President Constantine Simonides before going on to business school. Her place was taken by Elizabeth Reed, a graduate of Sarah Lawrence, who has been a valuable member of the Office's support staff since 1974. The responsibilities which Ms. Wells carried (chief among them the advising of students in architecture, urban studies, political science, economics, and the humanities) continue to be in very good hands.

ROBERT K. WEATHERALL

Personnel Office

The reports which follow highlight the past year in the sections that comprise the MIT Personnel Office. They report a year of consolidation and service to the community.

The past year involved continued efforts to develop an organizational structure that was flexible in meeting the changing personnel needs of the community. It was a time of change and new responsibilities for many individuals. It was also a period of expanded service with fewer staff members, a difficult task but one that must be accomplished in view of continued budget reductions.

Despite the major restructuring in Personnel Development the previous year, the Office was able to continue many of the existing development programs. Also, a major effort was undertaken to assess the training and development needs of the community. A diverse group of approximately 500 employees was interviewed to obtain their views on development needs. These views will contribute to the direction of training and development in the years to come, including a yearly training schedule available in September.

At the end of the year, the Personnel organization was restructured with the Benefits Office and the Wage and Salary Office being combined as the Office for Compensation and Employment. The consolidation reflects the Institute's need to plan and administer our compensation program
in a more integrated approach for wages and benefits. It is hoped that the consolidation of these groups will permit a broader outlook on equitable compensation patterns for the Institute.

While restructuring efforts are still not complete, the Office is moving toward a structure which has four major functions and components. These include the following:

**Compensation and Employment** with responsibility for salary, wage, and benefits administration for the total Institute and recruitment, referral, and employment approval for all nonacademic employees.

**Faculty and Staff Information Service** with the responsibility, through two sections, for the receiving, processing, and storage of employment information on faculty and staff. The office is also responsible for privacy of access to these records and for monitoring the employment and salary information for all members of the community. Service is provided through two units: the Faculty and Academic Staff Records Office and the Personnel Information Services Office.

**Labor Relations** with the responsibility for interpreting, negotiating, and administering all union/management agreements of the Institute. Presently the Institute has eight agreements with four separate unions.

**Personnel Services and Development** with the responsibility for development and interpretation of personnel policies and procedures, service to departments and employees, screening and referral of candidates for positions, and development and direction of training programs.

The Personnel Office also includes the Office of Child Care in its sphere of responsibility.

A number of changes in staffing occurred during the year. With the restructuring of Personnel Development, Maureen and Adam Yagodka, co-directors of Personnel Development, left the Institute to pursue other opportunities. Howard Hughes and Judy Silverman also left the Institute for other positions. Carolyn Scheer assumed a new role in updating Policies and Procedures, while Katherine Cochrane joined the Office of the Dean for Student Affairs. Richard Marvel, the Institute's Benefits Officer, also left to pursue opportunities in the private sector. Philip Robinson, Personnel Officer, left at the end of the year to pursue other opportunities. Other changes are listed in the section reports.

The objective of increasing personnel service to the community in a period of restrictive budgets requires creative leadership and extra effort. I would like to express my appreciation to the staffs of the sections comprising the Personnel Office for their skill and dedication in providing this leadership and meeting their objectives.

JAMES J. CULLITON

**COMPENSATION AND EMPLOYMENT**

**Benefits Administration**

The Benefits Office conducted a number of in-depth surveys with selected universities and other employers to determine how institutions are handling the pressures of inflation in relation to benefit programs. These surveys compared levels of benefits as well as benefit cost as a percentage of total compensation.

As a result of one of these surveys, we recommended that our tuition assistance benefit for non-MIT courses be increased from $900 to $1,000 per year. This change has been approved by the administration.

In the health insurance area, our objective for some time has been to have one level of coverage for all MIT employees -- this is already true for the MIT Health Plan and the Harvard Community Health Plan. In October 1980, we made major changes in the Blue Cross/Blue Shield Master Medical Program so that the staff and non-staff plans are now nearly identical, with the exception of outpatient psychiatric coverage.
Difficulties involved in equitably administering our health insurance plan with Blue Cross/Blue Shield led us to establish a claim review procedure to explore cases in which a participant feels that the payment was inadequate. This review allows for a more personal approach in which Blue Cross and Benefits Office representatives meet with the employee and attempt to resolve the issue with a minimum of time and paperwork.

The Benefits Office worked closely with our two approved tax-deferred annuity carriers in order to better educate the community about these programs. A redesigned workshop format on campus and at Lincoln Laboratory, along with more individual mailings and other publicity, resulted in a significant increase in participation in these programs.

Following an analysis of previous programs, we revamped the preretirement planning program in May 1981. By combining the traditional lecture approach with structured "pre-packaged" counseling materials, we made more effective use of planning resources. The overwhelming response has led us to consider offering the program more than once a year.

Wage and Salary Administration

The compensation structures of all categories of Institute faculty and staff were reviewed in relation to national and regional economic trends and competitive market conditions. As a result, suitable adjustments were made to existing salary scales. In addition, individual performance levels and job responsibilities of more than 5,000 salaried staff were reviewed, and appropriate merit increases were determined and put into effect.

These reviews included a detailed assessment of the Institute's faculty salary structure, which was compared to salary structures of more than 25 comparable universities across the country. This review indicated that the Institute continued to enjoy a generally strong overall salary position, but that it was at a disadvantage with respect to the salaries paid to junior faculty ranks. As a result of this data, a special effort was made, at the time of the annual review, to adjust the starting salaries of new assistant professors and to address the resulting compression effect caused by these adjustments.

The Staff Salary Administration Program, which was modified three years ago, continues to be successful. Over 270 positions have been reviewed by the Wage and Salary Section since this modification was implemented. Of these, 67 positions were reviewed this year, including 32 requests to evaluate newly established positions and promotional recommendations, and 35 requests to reassess existing positions. In addition to establishing equitable salary ranges, these reviews have been added to a large file of information concerning position requirements and responsibilities.

The support staff position standards continue to be most useful. They have proved to be fair and workable and have contributed substantially to equitable decisions concerning individual support staff positions. It is clear from our experience to date that these standards have also contributed to a more complete utilization of all salary ranges within the Institute's support staff classification structure. We continued our efforts to respond to persistent upward trends of starting rates in the marketplace by adjusting the salary ranges in the fall as well as at the time of the annual review.

Employment Activity

The nonacademic population on campus, as of March 1, 1981, was 5,239, an increase of 316 employees from the past year. Campus employment activity showed an 18 percent increase in the number of applications and an increase of 22 percent in the number of resumés received. Applicants totaled 4,060 for this year. Of these, 3,082 were interviewed by Personnel Officers (an increase of 14 percent over the number of interviews granted last year); and 2,922 of these applicants were referred to supervisors. From this pool, 941 were hired. This is a nine percent increase over last year's 859 hires. Additionally, more than 6,500 resumés were received, reviewed, and acknowledged with a personal letter. Of these, 4,526 were referred to supervisors for available positions in advance of personal interviews.
During this period, 805 MIT employees applied for transfers to other suitable positions at MIT. A total of 243 were successfully placed in new positions, a decrease from the past year's total of 276. The number of employees transferred and applicants hired combined was 1,184. This represents a four percent increase in total individuals hired this year compared to 1,135 reported last year.

Tech Talk job listings and MIT-related sources (MIT relatives and friends, former employees, and student referrals) accounted for over half of our applicants, while outside recruitment advertising (primarily in the Boston Globe and professional journals) generated approximately 39 percent of the applications and resumes received.

The MIT Personnel Office conducted a "Recruit a Friend" campaign during May and June in an effort to acknowledge and encourage the continuation of referrals by current employees. The campaign met with great success, resulting in the referrals of approximately 200 prospective employees within the seven-week period, 14 of whom have been hired thus far.

KERRY B. WILSON

LABOR RELATIONS

On June 20, 1981, seven out of eight union/management agreements with four separate unions expired. Negotiations are in progress with these unions, which represent 1,700 Institute employees. An agreement with a fifth union, the Campus Police Association, is in the last year of a three-year contract expiring on June 30, 1982.

Throughout the past 12 months, a non-negotiating year for the Office of Labor Relations (the first in six years), the administration of the eight union agreements has proceeded in a traditional manner. Grievances were somewhat fewer in number, with many being settled to the satisfaction of the parties or dropped by the unions. There are presently 22 grievances pending arbitration. Sixteen of these are related to bargaining unit work, an issue that has been a major source of disagreement between the Institute and the Research, Development and Technical Employees' Union for the past seven years. A more recent major disagreement with this bargaining unit centers around the union's desire to place restrictions on the Institute's right to use contract personnel. An arbitration is now pending on this subject. On both of these issues efforts are being made by the parties to find mutually satisfactory solutions. The grievance list includes work jurisdiction, discipline, management rights, and promotion issues for several of the bargaining units.

In February 1981, a dispute surfaced between the Institute and the United Food and Commercial Workers' International Union (Local 1445, AFL-CIO). The issue centers on the rights of a union attempting to organize Harvard Cooperative Society employees at the Tech Coop. Specifically, it deals with property rights of the Institute (right to private property) as they relate to legal rights of a non-MIT union to pass out handbills on Institute property. The case went before the National Labor Relations Board and the state courts in March 1981. A ruling from the Board has sustained the Institute's position. The court's decision, deferred until the Board made its ruling, should be rendered shortly.

JAMES J. FANDEL
PERSONNEL SERVICES AND DEVELOPMENT

Personnel Officers

Personnel officers have strengthened their efforts to provide personnel information and counsel to members of the MIT community. Changes have included expansion of departmental office hours, establishment of weekly orientation meetings for new personnel administrators, and the presentation of policy review sessions for supervisors.

The Office has endeavored to establish closer ties with senior officers in order to share their concerns regarding personnel matters, particularly in the area of affirmative action.

As in past years, personnel officers have concentrated their time on salary and classification reviews, applicant and transfer referral, and personal and career counseling. Additional interests have included representation on union negotiations committees, expansion of Institute recruiting efforts, presentation of résumé writing and interviewing workshops during IAP, and participation in the personnel development needs assessment survey.

RICHARD C. CERRATO
SALLY H. HANSEN
RICHARD E. HIGHAM

Development

A major effort was undertaken by the Office to assess the training and development needs of the community. A diverse group of approximately 500 employees had the opportunity to contribute ideas and suggestions through individual interviews, group meetings, and surveys. All interested members of the community who had not been formally contacted were invited to give their input via a Tech Talk article. The information received was reviewed to determine patterns of perceived need. In response to the needs identified, the Office will be offering a series of courses and programs in the fall of 1981 and the spring of 1982.

Two programs in financial management and two supervisory development programs were conducted on campus, and a program on equal employment opportunity was presented at the Lincoln Laboratory. Participant evaluation responses to these programs continue to be positive.

A short writing course, taught by Charles H. Ball, assistant director of the News Office, was very favorably received, as was a workshop on Making Decisions -- A Self Assessment, which was jointly sponsored with the Women's Forum during IAP.

JOAN F. RICE
SUSAN WARSHAUER

FACULTY AND STAFF INFORMATION SERVICE

Substantial headway has been made in the past year toward building a suitable infrastructure for a more modern set of information systems. There has been a certain measure of reorganization with a new alignment of some responsibilities. Elizabeth K. Mulcahy has been appointed manager of the Faculty and Academic Staff Records Office (FASRO), replacing Betty L. Hendricks. A restructuring of the Personnel and Employee Records (PERS) group is presently in process.
Practices and procedures are being modified in both PERS and FASRO to make the two records functions more compatible, and to reduce the complexity of the nascent computer-based information system. This is a matter of some delicacy, due to the necessity of balancing FASRO's need for "special handling" with the need for bringing the methods and practices of the two sections closer together.

Substantial effort has been expended in the past year to achieve a large improvement in the quality of the existing data base, diminishing the probability that we will "transplant" existing errors to the new files. There has been some interchange and reconciliation with other discrete data bases.

An on-line interactive query system operating under CMS and ADASCIPI+ has been commissioned and used to good effect for a number of statistical studies, and in support of labor relations work. The EASYTRIEVE utility has been implemented, which allows for a great deal more facility and freedom in support of the Office of Compensation and Employment.

GEORGE N. PETIEVICH

Faculty and Academic Staff Records Office

The Faculty and Academic Staff Records Office (FASRO) continued in its responsibility to the administration of the appointment process for all faculty and academic staff appointed at the Institute. As of October 1980, when the annual count of all faculty and academic staff was prepared, there was a grand total of 997 faculty members: 553 professors, 235 associate professors, and 209 assistant professors. Of this number, 68 percent had tenured appointments. The total count for all full-time and part-time faculty and other academic staff members as of that date was 2,846. Effective July 1, 1981, there were 15 promotions to professor, 32 promotions to associate professor, and 15 tenure cases approved. In addition, FASRO was responsible for the preparation of data for the "Personnel Changes" list for the faculty section as shown in the beginning of this Report.

This year FASRO also instituted new "Faculty and Academic Staff Appointment" forms as well as the "Personal Information and Change Notice for Faculty and Academic Staff" forms that are required for all new and current faculty and academic staff members. In addition to the regular appointment information contained on the forms, these new forms also provide FASRO with important MIT address and extension information as well as other useful information previously unavailable to the Office for telephone directory purposes, mailing lists, and other internal requests.

FASRO recently installed in the office the Adabas system, whereby the information input into the personnel data system via the Inforex system on all faculty and academic staff appointments can be easily queried and various reports generated. The word processor is also playing an important role in the information that FASRO generates to the Institute community.

FASRO is continuing in its endeavor to provide the Institute community with better service and more information regarding faculty and academic staff appointments. It is also becoming more involved in providing various statistical reports and counts requested by offices both within MIT and outside. In the near future, FASRO is looking forward to providing more and better service to the entire Institute community.

ELIZABETH K. MULCAHY

Personnel and Employee Records Section

The mission, operating mode, goals and objectives, and structure of the Personnel and Employee Records Section (PERS) is presently under review. Significant changes are anticipated which should enhance the efficiency, responsiveness, and cost effectiveness of this group.
The development of the personnel and employee records system, an on-line, interactive records and information system that will be implemented on the newly installed IBM 4341, has slipped somewhat in schedule while awaiting the assignment of appropriate technical personnel from MIT's Information Processing Services. It is anticipated that the assignment of technical personnel from IPS will permit the schedule to be resumed shortly.

Significant progress has been made to bring PERS practices into closer accord with MIT's policies on privacy and records management.

The volume of personnel action forms processed in PERS is in excess of 5,000 annually. This is the main interface between PERS and Payroll, several departments and laboratories, and other information-seeking groups in the Institute. The processing of personnel actions is the primary source of change to the files, which maintain records on 13,000 individuals, 7,600 of which are active records and subject to frequent change as new information develops.

References and verifications is another service provided by PERS, with a volume in excess of 5,000 transactions per year. In addition, PERS supports a semi-public photocopy facility, and shares word processor facilities with the Student Accounts/Student Loans sections of Student Financial Services. PERS maintains a stationery and supplies stockroom which supports the entire Personnel Office. PERS does the preprocessing of payroll vouchers, with a volume of several hundred per week. Production of letters in support of payroll status changes is being standardized, and we anticipate that through increased utilization of word-processor techniques, the amount of effort devoted to this task will diminish in the coming year. This group also continues to be concerned with privacy and records retention matters.

Data handling and services in support of salary review, the manufacture and distribution of mailing lists and labels, and general support of statistical studies continue to be major functions of PERS that support activities of the Personnel Office.

Production of the MIT staff Directory is undergoing a detailed review and evaluation, with the objective of simplifying and improving the procedures so as to reduce the effort involved.

CAROLYN A. SCHEER

CHILD CARE

The Child Care Office continues to meet the needs of the MIT community for child care services for young children.

During this past year, a total of 294 children used the MIT-related child care programs. An additional 375 families received assistance in finding programs located elsewhere.

As has been true in the past, most of the families (39 percent) who used on-campus services had student affiliations. Eleven percent had faculty affiliations, 18 percent had other academic appointments, 11 percent had administrative staff affiliations, nine percent were from the research staff, and 12 percent were from the support staff (an increase of two percent over last year). There was also an increase, from zero to 2.5 percent, in users from the service staff.

Family Day Care

Family Day Care (FDC), a home-based system designed primarily for infants and toddlers, accommodated 158 children. The number of very young children continues to increase -- children under eight weeks old, from 10 to 15 percent. The total number of children under 12 months went from nearly 50 percent to 64 percent.

Because of the increased demand in this age group, we experienced difficulty in recruiting sufficient numbers of MIT Family Day Care Providers. Since providers may not legally take care of more than two children under the age of two, we need a large number of homes to
accommodate all those children in this age group. The number of transfers within the program was down from last year -- from 63 to 45, which reflects less movement on the part of providers. Again, most of our family day care providers were graduate student wives. The program continues to be an important source of income for this group.

Technology Children's Center, Inc.

Technology Children's Center, Inc. (TCC), a private, non-profit corporation operating center-based programs on campus, provided care for 136 children between the ages of two years nine months and five years of age.

In addition to the full-day kindergarten program, the full-day preschool program, and the two nursery school programs, TCC started a third nursery school program to accommodate additional families at Westgate. This program will be offered again in the fall if there is sufficient demand for it.

This past year, TCC has taken on the coordination of a major project, the renovation of the Eastgate and Westgate playgrounds. Both playgrounds have become inadequate for the number and the age range of children using them, and present both developmental and safety problems. Working with the Housing Office and the Tenants associations at both buildings, TCC is coordinating the development of new plans, including fund raising, for this project.

New Directions

We have found ourselves with a substantial increase in the demand for care of children in the youngest age group -- under 12 months old. Since this age child is best accommodated through family day care, we have begun this year new initiatives to identify additional sources of family day care providers. Our efforts have followed two main thrusts: a close association with already existing family day care systems and programs, and the possibility of collaborations with other employers in the Kendall Square area. The development of this part of Cambridge will increase the number of child care spaces in Kendall Square and will impact on MIT child care users. We are looking at ways to accelerate the development of new spaces, particularly family day care spaces, by pooling the resources and expertise of companies already located in Kendall Square, as well as those who will be moving into the area over the next several years.

In conjunction with these moves, we are assigning one staff person in the Child Care Office to work exclusively on recruiting family day care providers from among the MIT community, particularly from among those living on campus.

MARGARET SAND

News Office

The 1980-81 academic year at MIT started, from a news standpoint, with the beginning of the administration of the Institute's new president, Paul Edward Gray. News media, both local and national, took note of the new administration in varying ways and depths. Much of the interaction was mediated by News Office staff members.

Other stories from MIT that reached public attention through the media included the visit of former Vice President Mondale, the unique observance of Martin Luther King Day at the Institute, and numerous stories growing out of scholarly pursuits by faculty. The latter included stories on space experiments, LNG and LPG transport, ethanol fermentation, George's Bank fishing prospects, OPEC analyses, several analyses of national economic problems, dangers of nuclear war, the future of diesel engines in automobiles, computer games for children, forecasts for uranium supplies, three-dimensional imaging via computer, energy policy issues, new alloys for fusion reactors, prospects for dealing with genetic defects in
humans, cardiac assist devices, undercover police work studies, a computer-simulated singing voice, and mid-life crises among managers.

News Office staff members continued to deal during the year with news media inquiries about the university, its people, and programs. No statistics are kept regarding these inquiries. The general impression, based on extrapolation of counts over short periods of time, is that the News Office deals with perhaps as many as 500 such inquiries per year.

During 1980-81, the News Office issued 147 press releases. Forty-eight of these dealt with the results of scholarly research and another 41 dealt with art, music, and related cultural events. Twenty-six announced important new appointments and 17 were about gifts to the Institute. The total number, and the number of art and music releases, were diminished somewhat because of the departure of staff member Paula R. Korn at the end of September.

The 1980-81 academic year marked the start of computerized typesetting for the community newspaper, Tech Talk, published by the News Office. As in any such technical conversion, there were -- and continue to be -- difficulties and strain. We are especially grateful to our editor, Joanne Miller, for her willing spirit and professionalism in overseeing the conversion without loss of a single issue. As planned, Tech Talk, was published 40 times during the year with an aggregate of 328 pages. Run-of-press reports included one from the Committee on Educational Policy, the triennial Independent Activities Period (IAP) report, and excerpts from the President's annual report to the faculty. Special supplements included one for Martin Luther King Day, one listing the Committees of the Institute, the Report of the President and Chancellor for 1979-80, the Affirmative Action Plan, and the Affirmative Action Plan for the Handicapped.

Subscriptions to Tech Talk climbed during the year to 562, a 21 percent increase. Those subscriptions paid for by individuals grew to 334, up 25 percent, while those paid for by offices within MIT grew to 228, up 15 percent. The lack of a second-class mailing permit for Tech Talk means that subscribers must continue to pay a fee adequate to have the newspaper delivered to them at first-class rates. (The Personnel Office continues to send Tech Talk to some 2,000 retirees each week, but those copies travel through the mails at third-class rates and speeds.)

Reports on Research, published by the News Office on behalf of the MIT Industrial Liaison Office, came out nine times during the year as planned (and as required by the Reports' own second-class mailing permit). It was quite often late, however, for several reasons. Staff members were not always able to find time to seek out, write, and clear articles as required, and articles left with faculty members for review and clearance were not always handled with dispatch.

Besides the departure of Ms. Korn and the consequent reduction in administrative staff, the News Office also had two changes in the support staff. Donna J. Dudzik, administrative secretary, left the Institute and was replaced by Donna R. Harris. Marsha G. McMahon, editorial secretary, left to join the MIT Joint Computer Facility and was replaced by Caridad T. Sritharan. Eileen J. Kennery joined the support staff part time to assist in electronic typesetting. Elizabeth C. Huntington, editorial assistant, assumed added responsibilities for publicizing art and music events. Assistant directors William T. Struble (School of Science), Robert C. Di Iorio (School of Engineering) and Charles H. Ball (School of Architecture and Planning, School of Humanities and Social Science, and School of Management) continued in their assignments as did Calvin D. Campbell, assistant director/photojournalist.

ROBERT M. BYERS

Campus Information Services

The past year was especially active for the Campus Information Services (CIS) -- that group of offices whose common goal is to provide information (to internal, national, and international "audiences") about MIT's programs, policies, organization, and services in ways which reinforce
and enhance the quality of the Institute. Each of the offices continued to work closely with each other, as well as with individuals and organizations throughout the Institute, to foster a shared understanding of MIT's programs, policies, and goals among the people who are here; and to provide information and services to visitors and to prospective students in ways which best meet their interests and needs. In addition to their ongoing activities, each of the offices within CIS was involved in a major way with activities surrounding the inauguration of Dr. Paul E. Gray as fourteenth president of the Institute.

During the early summer of 1981, with the guidance of the Vice President in the Office of the President, CIS began a process of strategic planning for the coming year(s) which will help to clarify priorities and goals for each of the offices, as well as to identify areas in which cooperation with other offices and programs may better serve the Institute's needs.

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 MIT Bulletin Office.

CONFERENCE COORDINATION

During the past year the Office of Special Events provided logistical planning and coordination for nine major research reviews or conferences of professional societies held on the MIT campus. These conferences included the Seventh International Conference on Atomic Physics, Conference on Fluidized Bed Combustion, Annual Conference of the International Committee on Thrombosis and Hemostasis, Annual Meeting of the Pi Lambda Phi Fraternity, Annual Conference of the American Physical Society, Conference of the Massachusetts Public Health Association, Amnesty International Conference, Conference on the Techniques for the Characterization of Composite Materials, and meetings in association with the Centennial Convention of the American Association of University Women.

Planning also continued for the several conferences already scheduled for the coming year.

In addition to conference activities, the office took on the responsibility for providing logistical support for the recruitment program of the Career Planning and Placement Service -- making all arrangements for group recruiting presentations by companies sending representatives to the campus to interview students. There were approximately 25 such presentations in both the fall and spring terms.

Throughout the year, there were continued efforts to achieve better coordination of conferences and special events on the campus and to establish ongoing communications with other offices having responsibilities for specialized "in house" conferences or activities. One step in this direction was the decision to move toward closer organizational ties between the Office of Special Events and the Information Center, whose director, Mary Morrissey, is responsible for much of the coordination of special Institute celebrations and events such as Commencement, new building dedications, and Killian Award lectures.

In April 1981, the Assistant for Special Events, Carole L. Taylor, left the Institute and was succeeded by Gayle M. Fitzgerald, who had been working on major conferences and reunion activities in the Alumni Association. Prior to her position in the Alumni Association, Mrs. Fitzgerald had provided secretarial and administrative support in the Office of Special Events. She was succeeded in that position by Stephanie Rutledge, who joined the office in November 1980.

DESIGN SERVICES

The Office of Design Services continues to assist the MIT community in the design and production of publications which reflect the quality of the Institute and, specifically, which reinforce the various arts programs at MIT. During the past year, the office, under the direction of Jacqueline Casey, undertook 544 graphic design and publishing projects. These publications
Campus Information Services

included assignments from many individual offices and departments within the Institute, including
the design and production of all material published for the inauguration of Dr. Gray as
president of the Institute. The office continues to provide design and production assistance
to the growing number of conferences held at MIT, and continues, as well, to coordinate the
design and production of the communications program of the Alumni Association.

In response to continued interest in Design Services posters as art prints, the MIT Press
Bookstore began carrying posters designed by Mrs. Casey.

In May 1981, Karin Baldwin, senior secretary, left the Institute to further her education.
She was replaced by Lee McMahon.

As in the past, many members of the office consulted on graphics and design projects with
other educational, cultural, and governmental institutions.

Professional recognition once again highlighted the design efforts of several members of the
staff during the past year. The work of Mrs. Casey, Ralph Coburn, Betsy Hacker, and Nancy
Pokross was broadly represented in major design exhibits, books, and journals. These include
the American Institute of Graphic Arts (AIGA) Graphic Design USA, one (Casey), Novum
Gebrauschgraphik and Idea Japan (Coburn), Graphis Annual (Pokross), New York Society of
Publications Designers (Pokross), and Art Directors Club of Boston, three Distinctive Merits,
eight Merits (Pokross).

Mrs. Casey was represented in several poster exhibits: Ephemeral Images, Recent American
Posters, Cooper Hewitt Museum, New York, 1981; AIGA Japan Exhibition, 1981; IV Poster
Biennale Lahti Museum, Finland; and the Colorado International Invitational Poster Exhibition,
Colorado State University, 1981.

Ralph Coburn served as a member of the awards panel for the traveling fellowship grants in
the Department of Art, Yale University, 1981.

THE INFORMATION CENTER

The Information Center in the past year has continued its role of service in three major areas:
public relations and information dissemination; coordination of many major Institute events;
and support for international faculty, staff, and visitors.

Although there were no major changes in organization, there was a shift in priorities and work
distribution. The Center was most fortunate in adding Lillian H. Whelpley to the staff.
She is helping both the director and the assistant for international visitors in the administration
of Center programs.

Besides gathering and distributing information, the public relations and information services
provided by the Center are varied and numerous. These include compiling information for
the MIT planning calendar, updating the Institute maps and visitors guides, coordinating
the student-run campus tours, maintaining the general Institute mailing lists, forwarding
Institute mail that has been addressed generally to MIT, maintaining Institute committee records,
and publishing a Tech Talk supplement of Institute committees.

The following is a general list of materials distributed from the Center:

Courses and Degree Programs issues 16,857
Reports 8,050
MIT maps and guides 31,896
Other publications 27,919

The Center has continued its tradition of hiring students to conduct the guided tours of the
campus. We were particularly fortunate this year in having 21 highly motivated student guides.
We received many compliments on their well-informed, competent, professional, and enthusiastic
efforts. Head guide, Susan M. Krolewski, G, ably handled the responsibility of assigning student tours. Special thanks also go to Karla M. Lehtonen and David A. Roth of the Class of 1983, for their public relations function in the Center, both in guided tours and in the office this past summer.

The following is a list of visitors to the MIT campus who took tours this past year:

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prospective students</td>
<td>2,468</td>
</tr>
<tr>
<td>International students</td>
<td>706</td>
</tr>
<tr>
<td>General visitors</td>
<td>3,579</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6,753</td>
</tr>
<tr>
<td>Visitors on special tours</td>
<td>995</td>
</tr>
<tr>
<td>Visitors on general tours</td>
<td>5,758</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6,753</td>
</tr>
</tbody>
</table>

Nick B. Adams, Class of 1981, served as the coordinator for Lobby 7 activities this past year. Geoffrey C. Frank, Class of 1983, will assume the role of coordinator this coming year and will work closely with the Lobby 7 Committee, which will become more active and supportive.

In the area of special Institute events, the highlight of the year, particularly for the director, was the inauguration of Dr. Gray, an event in which the Center played an important role and in which effective and creative administration was put to the test. A true sense of community emerged and almost all took part in one of the happiest and most celebratory occasions the Institute has ever had.

Commencement 1981 was the largest ever, with over 1,500 students receiving degrees in Killian Court. There were 45 children cared for at the child care center while proud parents watched the proceedings or received degrees at the ceremony. Special thanks go to Professor Roy Lamson, Eliot W. Goldstein, Class of 1981, Professor Samuel J. Keyser, Arthur Litchfield, Professor Warren M. Rohsenow, and Cy Tourtellot, who again donated their time and talent to play with the Intermission Trio at the reception immediately following the exercises.

Again special thanks go to the Information Center staff, whose spirit and loyal effort made everything possible. Donald Ferland, whose organizational skills, competence, and sense of humor are greatly appreciated; Kathleen M. Barrett, who at times has had to assume the major and lone role of carrying on the information dissemination role in the Center and always performs with graciousness and tact; Terri Priest, who along with her many other duties has the responsibility of hiring and training the MIT student guides, as well as efficiently and tirelessly handling the short-term international visitors who come to visit the campus; and Constance Cunningham, who succeeded Maureen McDonough in October as secretary to Virginia D. Lyons in supporting our international faculty and staff.

The International Section of the Information Center had another busy year during 1980–81. International staff and faculty increased to a total of 1,088, up 14 percent. Immigration applications for the 1980 calendar year totaled 22; 17 have been filed to date in 1981. Some of the activities that occurred in the International Section are listed below.

Regulatory Changes. The Department of Labor published its long-awaited changes in certification requirements, effective January 1981. Special handling provisions were established for faculty applications. The new regulations are more consistent with university recruitment procedures, and applications are being approved very speedily (averaging one month).

Applications for researchers have not fared as well, but efforts are still being made to combine the researcher regulations with the special provisions enjoyed by the faculty.

Regulations which made it difficult for Iranians to extend their stay, change visas, or obtain new visas at Consulates abroad were lifted several months after the hostages were released.

International Review. A review of the international aspects of MIT, conducted by Robert Weatherall, has occasioned meetings and discussions of problems, issues, and concerns related to the international community at MIT. A report and recommendations are expected during the coming months.
Chinese Exchanges. During the year more scholars from the People's Republic of China were attracted to MIT, with 105 scholars now in residence or en route. The majority of the scholars are funded by the Chinese government.

Information for International Visitors. Working with many offices throughout the Institute, Ms. Lyons prepared a brochure to alert prospective visitors to MIT of the high cost of living in the Boston/Cambridge area and the difficulty of finding housing. There has been considerable response from departments and laboratories which have requested the brochure for their visitors. A copy of the brochure is also being attached to each visa certificate.

National Association for Foreign Student Affairs (NAFSA). During the year, Ms. Lyons' NAFSA activities included chairing or serving on panels at regional and national conferences, and organizing an Immigration Workshop at Pine Manor College in April 1981, attended by 90 international student and scholar advisors from New England. In addition, she is a panelist on the Government Regulations Advisory Committee for 1980-82, and has been elected chairperson of the New England Region of NAFSA for 1982-83 (and serves as chair-elect, 1981-82).

MIT BULLETIN OFFICE

This year, the Bulletin Office edited and produced the Courses and Degree Programs catalogue, the Summer Session Catalogue, and the small and large versions of the Report of the President and the Chancellor. The office coordinated the production of the Student Directory and the small and large versions of the Report of the Treasurer. The Bulletin was also responsible for internal and external distribution of these publications.

As noted in our report last year, it was decided to combine the General Catalogue and Courses and Degrees into one book in 1980 which, it was hoped, would be more useful to both current and prospective students. The 1980-81 Courses and Degrees included both the detailed academic information that the book has always provided and also material on admissions, financial aid, campus activities, and housing, which was traditionally found in the General Catalogue. The new combined book was well received, and there are plans to publish only one large catalogue again for 1981-82.

Janet Snover, the Bulletin's Editor/Production Manager, and her assistant, Mark Wilson, provided editorial and production services and advice to other areas within Campus Information Services and to other parts of the Institute. Some examples of this assistance within CIS included work on conference publications, the Commencement program, Killian Lecture materials, Awards Convocation copy, and symposia and facility dedication materials. The Bulletin staff also provided editorial and production assistance to areas such as the Department of Urban Studies and Planning, the Undergraduate Research Opportunities Program (UROP), and the Office of the Dean for Student Affairs.

During the year, Ms. Snover was a member of the client team which worked with CV Films to produce a film targeted at prospective freshmen. The film, entitled "MIT Today," will be used by the Admissions staff when they meet with high school students considering MIT. The film will also be used at Alumni Association functions and will be shown to new MIT employees and visitors to the campus as another way to introduce them to the people and purposes of MIT.

In addition to her other responsibilities, Ms. Snover has begun investigating word processing systems and office automation, and will serve as a resource on these issues to the Vice President.

In January, Ms. Snover was elected to the Executive Board of the Council for the Advancement and Support of Education for District One (which includes New England and the Maritime Provinces). In this capacity she will help to organize conferences and other activities. She will also serve as co-chair of District One's Awards Committee.

KATHRYN W. LOMBARDI
Despite the generally unfavorable climate for scholarly publishing and a shortfall in backlist sales, the Press's overall financial performance slightly exceeded expectations. We continued to maintain our high level of production, design, and editorial standards, producing some of our finest books to date. The Press published a total of 122 books: 71 hardbacks, 30 new paperbacks, and 21 paperback reprints. A total of 434,169 copies were sold for a net income of $4,210,000. Both new and backlist paperback sales continued to increase, accounting for approximately 38 percent of sales, while backlist hardback sales declined for a second year, reflecting industry trends. Overall, international sales did well, representing approximately 28 percent of total sales. Sales of journals exceeded original forecasts, grossing a record $1,743,000 in income. One new journal was added, and planning for three more major journals was begun, including Robotics Research, a quarterly to be edited at MIT.

This year saw the opening of the MIT Press Bookstore, a retail outlet located in Kendall Square, with a complete backlist inventory. Sales for its first year of operation far surpassed the forecast.

As in the past, the Press received awards and recognition for book and jacket design, receiving a total of 31 awards. The largest number of awards was received from the Art Directors Club of Boston (ADCB), seven for book design and 10 for jacket design. Several books won multiple awards: both Complicity and Conviction: Steps Toward an Architecture of Convention by William Hubbard and Venetian Architecture by John McAndrew received awards from the ADCB, the Association of American University Presses (AAUP), and the American Institute of Graphic Arts (AIGA); Prehistoric Architecture in the Eastern United States by William Morgan won awards from the ADCB and the AAUP. Six Press books were featured in the New England Book Show: Complicity and Conviction by William Hubbard; Prehistoric Architecture in the Eastern United States by William Morgan; Toward a Solar Civilization edited by Robert Williams; Plasma Physics for Nuclear Fusion by Kenro Miyamoto; Evolution of Physical Oceanography by Bruce Warren and Carl Wunsch; and Venetian Architecture by John McAndrew.

The MIT Press Management Board met twice during the year. Members of the Board are Bradford Wiley, Chairman of John Wiley & Sons, Inc.; Alexander J. Burke, Jr., President of McGraw-Hill Book Company; Ann F. Friedlaender, Professor of Economics at MIT; Norman Pomerance, Senior Vice President of Harper & Row; and Alvin J. Silk, Professor of Management Science at the Sloan School; Hartley Rogers, Jr., Chairman of the MIT Press Editorial Board, and Frank Urbanowski, Director of the MIT Press, are ex-officio members. Constantine B. Simonides, Vice President in the Office of the President, is Chairman of the Board.

The Press concluded fiscal 1981 with a net operating loss of $161,900 on sales of $4,210,000. As it became apparent that hardcover sales would not meet original projections, the original sales forecast of $4,400,000 was reduced by $100,000 to $4,300,000. Although paperback sales continued to increase considerably, the income was not sufficient to close the year-end gap. The net loss, plus an additional $15,000 expense for the MIT Press Bookstore, was closed to the Development Fund, where previous years' surpluses have been retained for development of future publishing programs and opportunities.

During the year, the Press was able to maintain its working capital advances from the Institute below a $2,300,000 interest-free level, and therefore did not incur any interest charges. The MIT administration has agreed to adjust the interest-free level annually to maintain the current dollar value of the $2,000,000 level originally approved in fiscal 1980.
Fiscal Year 1981

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Original Budget</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Net Sales</td>
<td>$4,210,000</td>
<td>$4,400,000</td>
<td>$4,031,000</td>
</tr>
<tr>
<td>Cost of Sales</td>
<td>1,714,500</td>
<td>1,802,000</td>
<td>1,512,700</td>
</tr>
<tr>
<td>Gross Margin</td>
<td>2,495,500</td>
<td>2,598,000</td>
<td>2,518,300</td>
</tr>
<tr>
<td>Other Income</td>
<td>37,000</td>
<td>40,000</td>
<td>40,300</td>
</tr>
<tr>
<td>Total Income</td>
<td>2,532,500</td>
<td>2,638,000</td>
<td>2,558,600</td>
</tr>
<tr>
<td>Operating Expense</td>
<td>2,694,400</td>
<td>2,692,000</td>
<td>2,402,700</td>
</tr>
<tr>
<td>Net-Books Division</td>
<td>(161,900)</td>
<td>(54,000)</td>
<td>155,900</td>
</tr>
<tr>
<td>Percent Net Sales</td>
<td>(3.8%)</td>
<td>(1.3%)</td>
<td>3.9%</td>
</tr>
</tbody>
</table>

BOOK PROGRAM

The Press continued to emphasize careful planning and development of more focused lists. Several years of attention to the economics and computer science lists are beginning to show results, and fledgling lists such as health science and popular science promise long-term rewards. Two new editors were hired, one for the economics and business list and the second for linguistics and cognitive sciences, where we expect a significant increase in acquisitions of books.

The Press also purchased Bradford Books, the firm operated by Henry and Elizabeth Stanton, which will be included as a series in our book program. Bradford Books specializes in the behavioral sciences, linguistics, artificial intelligence, cognitive science, computer science, and the neurosciences. Its second title *Brainstorms* by Daniel Dennett, which is now in its fourth printing, has become something of a contemporary classic, having sold over 14,000 copies since it was published. Other outstanding books in the series are *Mind Design* edited by John C. Haugeland and *Commissurotomy: Consciousness and Unity of Mind* by Charles E. Mark.

New Books Published in Fiscal Year 1981

<table>
<thead>
<tr>
<th>Category and Subject Area</th>
<th>Scholarly and Professional</th>
<th>Reference</th>
<th>Text</th>
<th>Trade</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hard/Paper</td>
<td>Hard/Paper</td>
<td>Hard/Paper</td>
<td>Hard/Paper</td>
<td>Hard/Paper</td>
</tr>
<tr>
<td>Architecture and Urban Studies</td>
<td>7</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Economics, Business and Social Science</td>
<td>15</td>
<td>4</td>
<td>-</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Applied Mathematics and Physical Sciences</td>
<td>7</td>
<td>-</td>
<td>2</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Electrical Engineering and Computer Science</td>
<td>5</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Engineering</td>
<td>8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Health Sciences and Technology</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cognitive Science, Linguistics, AI and Psychology</td>
<td>4</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Humanities</td>
<td>4</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Totals</td>
<td>52</td>
<td>9</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Totals Combined</td>
<td>61</td>
<td>4</td>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Trade books continue to be some of the most visible books the Press publishes, and among the outstanding ones published this year were *The Copyright Book* by William S. Strong, which has sold almost 3,000 copies in its first two months of publication; and *The Grand Domestic Revolution: A History of Feminist Designs for American Homes, Neighborhoods, and Cities* by Delores Hayden.
which received front-page reviews in the New York Times Home section. Several were tremendously well received: John von Neuman and Norbert Wiener by Steve Heims, which has sold 3,000 copies in its first year of publication, was widely reviewed and was chosen as one of the inaugural selections of the Book-of-the-Month's new Science Club; the History Book Club made a very rare purchase of Thomas Alva Edison: An American Myth by Wyn Wachhorst, taking 2,500 copies to offer as an alternate selection; and Complicity and Conviction: Steps Toward an Architecture of Convention by William Hubbard, was featured in the New York Times Book Review, and received design awards from the ADCB, the AAUP, and the New England Book Show. Other important books were Polywater by Felix Franks, which was reviewed by Discover magazine, and The Atom Besieged: Extraparliamentary Dissent in France and Germany by Dorothy Nelkin and Michael Pollack, featured in the spring books issue of Science.

Among the notable paperbacks published this year, which continue to grow in importance as a part of the Press's program, were The Microelectronics Revolution by Tom Forrester, which has sold almost 2,000 copies this year, and the second edition of Herbert Simon's The Sciences of the Artificial. Several from the Press's backlist were reprinted in hardcover. These included: The Glass House by John Hix; and The Computer Age: A Twenty-Year View, by Professors Michael L. Pertouzos and Joel Moses, which has sold 7,000 copies. The popular Encyclopedic Dictionary of Mathematics edited by Shokichi Iyanaga and Yukiyosi Kawada, was offered in paperback for the first time, making it more available to individual mathematicians, and has sold almost 3,000 copies. It also received an award from the Art Directors Club of New York. North-South: A Program for Survival continues to do very well, having sold 38,916 copies since it was first published a year and one-half ago.

Scholarly and professional books remain the core of the Press's program. Among the outstanding books produced this year were From Art to Science: Seventy-Two Objects Illustrating the Nature of Discovery and A Search for Structure: Selected Essays on Science, Art, and History, both by Cyril Stanley Smith, Institute Professor, Emeritus; each was reviewed by Harper's, and publication was marked by a very successful celebration held at the President's house in May. Others included The Photic Field by Parry Moon, Professor, Emeritus in the Department of Electrical Engineering and Computer Science, and Donna Spencer, culminating their years of work on the formal study of radiant energy; the first of four Le Corbusier Sketchbooks, published in conjunction with the Architectural History Foundation and the Foundation Le Corbusier; A Theory of Good City Form by Kevin Lynch, Professor, Emeritus of City Planning at MIT, which appeared 21 years after his first book The Image of the City, marking two decades of distinguished publishing in architecture and urban design by the MIT Press; Continuum Electromechanics by James Nielson, Professor of Electrical Engineering at MIT, the result of almost a decade of work; and Evolution of Physical Oceanography: Scientific Surveys in Honor of Henry Stommel, edited by Bruce A. Warren, senior scientist at Woods Hole and Carl Wunsch, head of the Department of Earth and Planetary Sciences at MIT.

Development of series has become more focused over the past several years, resulting in the publication of several outstanding books this past year. Among them were Turtle Geometry: The Computer as a Medium for Exploring Mathematics by Professors Harold Abelson and Andrea diSessa, which was reviewed by the Christian Science Monitor and received major endorsements (Artificial Intelligence Series); and a three-volume edition of the Collected Papers of Richard Brauer edited by Richard Brauer, Warren J. Wong, and Paul Fong (Mathematicians of our Time Series). Others published within series were The U. S. Coal Industry by Martin Zimmerman (Energy Laboratory Series); Centerbeam by Otto Piene and Elizabeth Goldring (Exhibition Catalogues in the Visual Arts); Miles To Go: European and American Transportation Policies by James Dunn (MIT Press Transportation Studies Series); Health Policy and Bureaucracy: Politics and Implementation by Frank J. Thompson (MIT Studies in American Politics and Public Policy); Studies in Abstract Phonology by Edmund Gussman (Linguistics Inquiry Monograph Series); and Software Metrics by Alan Perlis, Frederick G. Sayward, and Mary Shaw (MIT Press Computer Science Series). Inaugural books of new series were Cable Structures by Hilary M. Irvine (Structural Mechanics Series); and Freight Transport Regulation: Equity, Efficiency, and Competition in the Rail and Trucking Industries by Ann Friedlaender and Richard H. Spady and The SEC and the Public Interest by Susan M. Phillips and J. Richard Zecher (Regulation of Economics Activity Series). The first two books for Studies in Contemporary German Social Thought are due in the fall and 10 more projects are in process.
New series in which titles will appear in 1981 or 1982 are Cognitive Theory and Mental Representation, (S.J. Keyser, J. Bresnan, and L. Gleitman, editors), and Organization Studies Series, (John van Maanen, editor).

MIT Press series editors are Patrick Henry Winston and John Michael Brady (Artificial Intelligence); Samuel Jay Keyser (Current Studies in Linguistics, Cognitive Theory and Mental Representation, and Linguistic Inquiry Monograph); Jay W. Forrester (MIT Press/ Wright Allen Series in System Dynamics); Alan S. Willsky (Signal Processing, Optimization, and Control); William E. Griffith (Studies in Communism, Revisionism, and Revolution); Professor Marvin L. Manheim (Transportation Studies); Professor Hilary M. Irvine (Cable Structures); Jeffrey Harris (Health and Public Policy); Richard Schmalensee (Regulation of Economic Activity); Bernard Frieden (Housing and Urban Policy); Michael Folsom (Documents in American Industrial History); and Thomas McCarthy (Studies in Contemporary German Social Thought).

Faculty serving on the MIT Press Editorial Board in 1980-81 were Professors Suzanne Berger, Joan W. Bresnan, Fernando Corbato, Carl Kaysen, Leo Marx, Ernest Moniz, William L. Porter, Ascher Shapiro, and Robert Weinberg. Jay K. Lucker, Constantine B. Simonides, and Frank Urbanowski served as ex-officio members. Professor Hartley Rogers, Jr., is Chairman of the Editorial Board.

Acquisition editors are Frank Satlow (Engineering and Computer Science); Laurence Cohen (Physical Science and Applied Mathematics); Roger Conover (Architecture, Urban Planning, and Design); Grahame Smith (Life Sciences and Health Policy, Technology and Management); Sharon Basco (Popular Science); Robert Bolick (Business, Economics, and Social Science); Bruce Katz (Linguistics and Philosophy); Henry Stanton (Bradford Books); and Muriel Cooper, who is leaving the Press but will continue as series editor and consultant for special projects in visual communication.

BOOK PRODUCTION

Under the direction of Helen Osborne, managing editor, and Richard Wolflein, production manager, the editorial and production staffs produced 122 books in a broad range of topics. Many books were reprinted this year, including three which were published this fiscal year and sold out in their first three months of publication: The Domestic Revolution by Delores Hayden, The Defense Industry by Jacques Gansler, and John von Neuman and Norbert Wiener, by Steve Heims.

The Press's new computer composition and editing facility is in its final stages of testing, and Mildene Bradley, manager, expects the system to be delivered and installed by early fall 1981. It has taken the Press well over two years, working with Penta Systems International and Autologic, Inc., to achieve our specifications for the system, but the results will allow us to typeset an increasing number of books and journals in-house while maintaining our high standards of book design and production. Once Computergraphics is running smoothly, there will be opportunities to experiment with more advanced applications of technology (remote terminals, telecommunications, and long-term storage and revision of reference works).

As in past years, the Design Department, under the management of Sylvia Steiner, produced many books which received recognition for book and jacket design, capturing multiple awards from the ADCB, AAUP, and The American Institute of Graphic Arts. Several books were also featured in the New England Book Show. Donna Schenkel, assistant manager of the Design Department, received two awards from the ADCB, a silver medal for Venetian Architecture by John McAndrew, and a Distinctive Merit award for the jacket of The Avant-Garde in Russia, 1910-1930 by Stephanie Barron and Maurice Tuchman.
Sales for fiscal year 1981 improved slightly over the previous fiscal year, due in part to the combined efforts of the Press's promotion and sales staff (Thomas McCorkle, marketing manager and Brooke Stevens, promotion manager). However, general economic conditions and tight institutional budgets did have a dampening effect on the overall growth of the Press, as evidenced in the following.

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Fiscal Year 1981</th>
<th>Fiscal Year 1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>College Bookstore</td>
<td>$734,601</td>
<td>$723,852</td>
</tr>
<tr>
<td>Retail Bookstore</td>
<td>840,103</td>
<td>800,906</td>
</tr>
<tr>
<td>Wholesale and Jobber</td>
<td>783,168</td>
<td>717,111</td>
</tr>
<tr>
<td>College and University Library</td>
<td>109,192</td>
<td>117,941</td>
</tr>
<tr>
<td>Direct Mail</td>
<td>257,450</td>
<td>296,295</td>
</tr>
<tr>
<td>Other</td>
<td>333,696</td>
<td>324,586</td>
</tr>
<tr>
<td>Totals</td>
<td>$3,058,120</td>
<td>$2,980,691</td>
</tr>
</tbody>
</table>

Since 1977, unit sales have remained fairly constant. But distribution of these sales between hardback (sold primarily to libraries) and paperback has shifted dramatically. In 1977, we shipped 173,964 hardcover and 163,900 paperbacks. By 1981, hardcover shipments had dropped by 25 percent to 129,987, and paperback shipments had increased by 59 percent to 259,875. Shrinking library budgets, as well as economic conditions, have added to this trend. Percentage distributions are given in the following table.

<table>
<thead>
<tr>
<th>Fiscal Year 1977 - Fiscal Year 1981</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hardcover</strong></td>
</tr>
<tr>
<td>units</td>
</tr>
<tr>
<td>1977</td>
</tr>
<tr>
<td>1978</td>
</tr>
<tr>
<td>1979</td>
</tr>
<tr>
<td>1980</td>
</tr>
<tr>
<td>1981</td>
</tr>
</tbody>
</table>

Direct Mail

A total of 450,000 brochures and catalogues were mailed this year. Although this represents an increase of 75,000 mailings over last year, direct mail income decreased from a total of $300,000 for fiscal year 1980 to $250,000 for fiscal year 1981. Two clearing house sales and 100,000 pieces soliciting examination inquiries and text adoptions accounted for approximately half of this income. The most profitable mailing was traced to the paperback edition of *The Encyclopedic Dictionary of Mathematics*, which contributed a total of $25,000 to overhead.

Advertisements for new books were placed in 90 trade, scholarly, and professional publications, and new books received major review coverage throughout the nation, in such publications as *The New York Times*, *the Chicago Tribune*, *Newsweek*, *Discover*, *Science 81*, and *The New Yorker*. The Press participated with its own book display in 13 professional and trade meetings, and sent books through trade services to many others throughout the country.
Texts

Under the direction of Nancy Greenhouse, texts and exhibits manager, the Press books continue to be widely adopted for course use, particularly paperbacks as supplementary texts. Sales of 80,000 units of the Press's 12 best-selling paperbacks accounted for 28 percent of total paperback sales. Site Planning, revised second edition by Kevin Lynch, continues to be the best selling hardcover title, which has sold more than 50,000 copies since its publication in 1977. Other widely adopted recent texts include Analysis of Cross-Classified Categorical Data, second edition by Stephen Fienberg, and Complicity and Conviction: Steps Toward An Architecture of Convention by William Hubbard. Books published in fiscal year 1981 for which strong adoptions sales are anticipated, included International Trade edited by Jagdish Bhagwati and Sciences of the Artificial, second edition by Herbert Simon.

International Sales and Subsidiary Rights

International sales represented approximately 28 percent of total sales for fiscal year 1981, with sales in Latin America and Canada showing especially large increases. Sales through the London office to the United Kingdom and continental Europe registered a modest gain, while sales in Australia remained static.

Under the direction of Don Stanford, assistant sales manager for International Sales and Subsidiary Rights, MIT Press continues to strengthen its export marketing organization. In cooperation with the university presses of Chicago, Harvard, and Yale, a highly qualified Canadian sales representative was hired to provide a closer and more constant liaison with Canadian booksellers. At year's end, final steps were being taken toward establishing a Japan sales office, to be based in Tokyo and staffed by two Japanese nationals with long experience in the book trade. The university presses of California, Chicago, Harvard, and Yale will share the services and expenses of the office with the MIT Press.

China presented two unusual opportunities for dissemination of information on MIT Press titles. The AAUP coordinated production of a combined university press book catalogue which was widely distributed throughout China. Descriptions of 59 MIT Press titles appeared in the catalogue and resulting sales were approximately $20,000, the largest amount realized by any of the presses represented in the catalogue. The Press also participated in a massive six-city book exhibit sponsored by the Association of American Publishers and the China National Publications Import Corporation. The exhibit contains 113 recently published MIT Press titles.

### International Sales, Fiscal Year 1979 - Fiscal Year 1981

<table>
<thead>
<tr>
<th></th>
<th>Fiscal Year 1981</th>
<th>Fiscal Year 1980</th>
<th>Fiscal Year 1979</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>24,000</td>
<td>25,000</td>
<td>40,000</td>
</tr>
<tr>
<td>Canada</td>
<td>177,000</td>
<td>149,000</td>
<td>117,000</td>
</tr>
<tr>
<td>Japan</td>
<td>203,000</td>
<td>182,000</td>
<td>160,000</td>
</tr>
<tr>
<td>Rest of Asia and Other</td>
<td>119,000</td>
<td>106,000</td>
<td>131,000</td>
</tr>
<tr>
<td>Latin America</td>
<td>64,000</td>
<td>39,000</td>
<td>50,000</td>
</tr>
<tr>
<td>UK, Europe, Africa, and Middle East</td>
<td>655,000</td>
<td>623,000</td>
<td>550,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,242,000</strong></td>
<td><strong>1,124,000</strong></td>
<td><strong>1,048,000</strong></td>
</tr>
</tbody>
</table>

As anticipated, subsidiary rights income declined in fiscal year 1981 because of a decrease in sales of paperback reprint rights. Since paperback books are becoming more important to the Press's total operation, reprint rights are being sold to other publishers only for large advances (minimum $25,000). Gains, however, were made in other areas, particularly in book club sales, which increased 45 percent over last year. The Book-of-the-Month Club chose John von Neuman and Norbert Wiener by Steve Heims as an inaugural selection for its new Science Club; Beyond Orpheus by David Epstein was a main selection of Macmillan Book Club's Music Book Society; Thomas Alva Edison by Wyn Wachhorst was offered as an alternate
selection by the History Book Club; and Cable Structures by Hilary M. Irvine was purchased by Macmillan Book Club for its Professional Civil Engineering Book Club (150 copies) and McGraw-Hill Book Club for its Civil Engineers Club (300 copies).

### Subsidiary Rights

<table>
<thead>
<tr>
<th></th>
<th>Fiscal Year 1981</th>
<th>Fiscal Year 1980</th>
<th>%Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Translation Rights</td>
<td>$38,497</td>
<td>$37,400</td>
<td>+03</td>
</tr>
<tr>
<td>Book club Rights</td>
<td>18,438</td>
<td>12,700</td>
<td>+45</td>
</tr>
<tr>
<td>Reprint Rights</td>
<td>23,066</td>
<td>35,500</td>
<td>-35</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$80,001</strong></td>
<td><strong>$85,600</strong></td>
<td><strong>-07</strong></td>
</tr>
</tbody>
</table>

THE MIT PRESS BOOKSTORE

On November 24, 1980, the MIT Press opened its own retail outlet, the MIT Press Bookstore, in the rapidly developing Kendall Square area. Under the planning and development of Lawrence Killian, the bookstore was designed as a display room for all Press titles as well as a place to host author receptions and publication parties. Customer response has been overwhelming, and sales for the first seven months have exceeded the most optimistic projections by 25 percent, with gross sales of $47,501 on 4,343 units; sales show no sign of leveling off.

The best-selling paperback was *The Computer Age: A Twenty-Year History* by Professors Michael Dertouzos and Joel Moses, and the best-selling hardback was *John von Neuman and Norbert Wiener* by Steve Heims.

### Percentage Distribution of Sales

- Fine Arts: 5%
- Philosophy/Aesthetics: 1.95%
- Language/Linguistics: 6%
- Architecture: 8.57%
- Urban Studies: 8.98%
- Energy: 2.7%
- Environment/Earth Science: 3%
- Social Studies: 2.8%
- Political Science/International Studies: 7.96%
- Business/Labor/Economics: 6.87%
- Science/Technology: 11.69%
- Mathematics/Statistics: 5%
- Physics/Astronomy: 2.2%
- Biology/Medical/Health: 2.78%
- Neuroscience: 1.69%
- Computer Science/Systems: 12.71%
- Engineering: 10.1%

Since its opening, analyses of clientele and markets have shown the need for scholarly and technical publications not normally available through local trade bookstores. In addition to its own books and journals, the Bookstore also carries study guides published by MIT's Center for Advanced Engineering Study, the *Sloan Management Review*, and *Technology Review*.

JOURNALS

The Journals Department of the Press achieved sales ahead of the projected budget for fiscal year 1981, and produced the first net gain in operations since the establishment of the program. The modest gain was $5,000 (compared with a projected deficit of $70,200). An additional $84,000 was added to the reserve account (unearned subscription revenues) bringing it to $597,000 (projected increase was $507,000), and total earned income for the year was $1,559,000 (compared with a projection of $1,515,000).
One new journal, *The Drama Review*, (formerly *The Tulane Drama Review*, a prestigious journal devoted to the theatre) edited by Michael Kirby, was added to the department in March 1981. Groundwork also began for the initiation of a new journal, *Robotics Research*, to be edited by Richard C. P. Paul and J. Michael Brady (of MIT); the first issue is due to appear in March 1982. A grant from the National Endowment for the Arts (NEA) was received for establishment of an American office for the Italian journal *Spazio e Societa*, and the eventual bilingual publication of the quarterly. Julian Beinart of MIT will serve as the American editor.

The other journals in the program are *Linguistic Inquiry*, edited by S. J. Keyser; *Journal of Interdisciplinary History*, edited by Robert I. Rotberg and Theodore K. Rabb; *Oppositions*, edited by Peter Eisenman et al.; *October*, edited by Annette Michelson and Rosalind Krauss; *The Milbank Memorial Fund Quarterly/Health and Society*, edited by David P. Willis; *International Security*, edited by Michael Nacht and Albert Carnesale; *Neurosciences Research Program Bulletin* edited by George Adelman; *Science, Technology and Human Values* edited by Marcel LaFollette; *Via*, sponsored by the Department of Architecture, University of Pennsylvania; *Perspecta: Yale Papers in Architecture*, sponsored by the School of Art and Architecture at Yale University; *Harvard Architecture Review*, sponsored by the Graduate School of Design at Harvard University; and *Cell*, edited by Benjamin Lewin.

*Computer Music Journal* was fully integrated into the program this year; it also made national news with two special issues focused on artificial intelligence and the sound sheet, which was featured in volume four, number four of the journal. The January issue of *Cell* created front-page news in *The New York Times* when it became the first serious scientific journal to report on the successful cloning of a mammal. The international audience for the journal continues to grow and the circulation reached 4,300 this year.

An interesting development was the increased newsstand distribution of the journals *International Security* (1,500 copies); *October* (1,300 copies); *The Drama Review* (1,000 copies); and *Computer Music Journal* (1,000), as well as the healthy growth in sales of the architecture annuals. *The Harvard Architecture Review* #1 had a brisk sale and was reprinted within the year.

Fiscal year 1981 was the first full operational year for Scribe Computer, Inc., the on-line minicomputer system designed especially for subscription fulfillment, which was acquired by the Journals Department in November 1979. The system attracted attention among journals publishers throughout the nation, and within the year representatives from a number of publishers, including John Wiley & Company, Cambridge University Press, the University of Chicago Press, Harvard University Press, and the University of California Press visited the Journals Department and received demonstrations of the system, supervised by circulations manager, Kathy Murphy.

The Journals staff, including manager Ann Reinke, production manager Christine Lamb, promotion manager Julie Zuckman, and circulation manager Kathy Murphy, presented the program on journals publishing at the 1981 Radcliffe publishing procedures course.

FRANK URBANOWSKI

Quarter Century Club

The MIT Quarter Century Club was founded in 1950 and became an Institute administrative department in 1978, reporting to the Vice President in the Office of the President.

The activities of the Club can be categorized into three main areas. It provides a service to its members, to the Institute community, and to the alumni of the Institute.

In the spring an annual meeting is organized. It is at this meeting that new members are inducted into the Club. A summer picnic is held in August, and a holiday meeting takes place in December. Other services are provided to members routinely by request.
Vice President in the Office of the President

The Club provides a service to the Institute through administrative and logistical support to the Institute's annual charitable campaigns, to a biennial employees open house, and to its annual retirement dinner. In the past, the Club has been asked to organize additional special meetings of an Institute-wide nature.

A number of international and national trips designed for the greater MIT community are sponsored each year by the Club. These trips are usually for vacation purposes, but the Club also provides travel assistance, on request, to other groups within the Institute.

The Club has given assistance to various departments planning educational exchanges to other countries and to the Alumni Association for alumni club activities.

Several personnel changes occurred during the year. Philip A. Stoddard was elected chairman of the Board of Directors to fill the post formerly held by the late Robert J. Radocchia. In April, John E. Newcomb relinquished his duties as executive director to devote his full energies to the Center for Advanced Engineering Study. The staff of the Club now consists of Ann Perkins, office manager, and two staff assistants, M. Frances Daly and Nanci Drago.

The membership of the Club now totals over 1,400 members, each member having served the Institute for more than 25 years.

PHILIP A. STODDARD

Council for the Arts

In its eighth operating year, the Council was largely devoted to fundraising efforts for the proposed Arts and Media Technology facility and to increased programmatic activities for the Council membership and the MIT community as a whole.

The year began with a major change of leadership. Shortly after Paul E. Gray became MIT's fourteenth President, Jerome B. Wiesner succeeded Luis A. Ferré, Class of 1924, as chairman of the Council. Governor Ferré joined Paul Tishman, Class of 1924 and the Council's founding chairman, as honorary chairman and a continuing member of the Executive Committee. Vice chairman Kay Stratton and other committee chairmen continued in their posts at the request of Dr. Wiesner.

Membership

Fourteen new members were appointed to the Council for three-year terms by President Gray. They are: Leo Beckwith, Pierre Boulez, William Hecht, Rosalind Jacobs, Gyorgy Kepes, Solomon Manber, Alan May, Walter Rosenblith, Eugene Schnell, Malcolm Schoenberg, Ascher Shapiro, Elsa G. Sonnabend, John Stern, and Albert Weis. President Gray also became a member of the Council.

Maria Bentel, John MacFadyen, Robert Rudy, and Sherwood Stockwell concluded their terms of membership with the end of the year. The Council was greatly saddened by the deaths of two of its members: in July 1980 by that of Mrs. Jo Pomerance, best known as a leader in the American peace movement and a co-founder of the Committee for World Development and World Disarmament; and in April 1981 by that of Dr. Rudolf E. Gruber, Class of 1916, and a strong supporter of MIT's music program.

At the year's end Council membership stood at 94.
Ninth Annual Meeting

The Council's ninth annual meeting was held on November 21 and a record number of Council members and spouses were welcomed by President Gray. In his opening address, Dr. Gray stated: "Just as the arts can make the point in our education that human values permeate the MIT curriculum, so the Council can help demonstrate to a skeptical public that MIT is a place where human creative values inform the entire range of intellectual disciplines and contribute to the complete education of our students."

After the annual business meeting and committee reports, the Council heard Dr. Wiesner and Dean William L. Porter describe the revised planning efforts of the Arts and Media Technology building, which incorporates the program in a more compact and efficient design. Council members then adjourned to Hayden Courtyard to attend the dedication ceremonies for The Bather, by Jacques Lipchitz, a major new acquisition to the MIT permanent collection donated to the Institute by Council member Yulla Lipchitz in honor of Paul and Ruth Tishman and in celebration of their long friendship with her late husband and herself.

Five groups of Council members convened with faculty and students at luncheon/workshop sessions to explore MIT arts activities. The workshops included: the Visual Arts with Director of Exhibitions Kathy Halbreich; Film/Video with Professor Richard Leacock; Three-dimensional Imaging Techniques with Technical Instructor Scott Fisher; Urban Tissues with Professor John Habraken; and Electrographics with Professor Muriel Cooper. In the afternoon, a panel session moderated by MIT's Provost, Professor Francis E. Low, examined the role of the arts in education from a variety of academic perspectives. Topics discussed ranged from the often uneasy balance between extracurricular and curricular arts programs to new forms of education and research in the arts. In the evening, the Council met at the President's House for its annual dinner and presentation of the Eugene McDermott Award. Luis A. Ferré, the Council's retiring chairman, former Governor of Puerto Rico and founder of the Ponce Museum of Art, received the seventh McDermott Award from Dr. Wiesner and Mrs. Margaret McDermott. Mr. Ferré gave his response in the form of a short Beethoven piano piece and was also given a standing ovation.

Fundraising Activities

The Facilities Sponsoring Committee, under the chairmanship of Vernon Alden and with leadership from Dr. Wiesner and Professor Nicholas Negroponte, accelerated the intensive fundraising effort in support of the Arts and Media Technology Facility. To date, the Institute has received commitments for over half of the total project cost of $20 million, with numerous other proposals being considered. Of the 32 gifts and pledges, 10 are from foundations, eight are from corporations with interest in communications, and 14 are from individual donors. MIT's challenge grant of $250,000 from the National Endowment for the Arts was matched four to one in new and increased funds.

Under the chairmanship of Gregory Smith, the Development Committee continued to expand the program of annual giving and to explore individual, foundation, and corporate gifts in support of the Council's Grants Program. Two-thirds of the Council membership made gifts to the Council and Council-sponsored activities, thereby contributing 57 percent of the total operating budget.

The Council's second endowed fund was established by Mrs. Eugene McDermott as a means to enhance the Eugene McDermott Award, traditionally presented at the annual meeting.

Additional funds were raised to support special projects within several academic programs, representing the largest contribution of this nature by the Council to date. Among these funds was a three-year grant from the Louis B. Mayer Foundation to support the weekly public screening series presented by the Film/Video Section. Additional contributions included a three-year grant from Karmazin Products Corporation to support a music research project in the Research Laboratory of Electronics, a grant from the MacArthur Foundation for the Experimental Music Studio, and two grants from the Samuel C. Endicott Foundation to support
projects within the Music Section. Gifts from two Council members to the Committee on the Visual Arts helped frame works of art from the Student Loan Collection, and four other Council members donated prints and major works of art to the Institute.

Grants Program

At its three regular meetings during the academic year the Grants Committee, chaired by Lewis Cabot, made 27 grants to student, faculty, and staff projects in the arts at MIT. Slightly over $39,000 was allocated, which generated more than $68,000 in matching funds. Competition for Council funding continued to increase as proposals rose both in quality and in number. The 27 grants awarded represented 56 percent of the requests made; 23 of these were made on the matching principle in dollars or in-kind services. Each member of the Grants Committee visited one or more of the applicants to discuss proposals in greater depth, thereby supplementing each proposal with a site visit.

Among the most interesting grants this year were three collaborative projects with outside arts organizations. Partial matching support was awarded to the Undergraduate Association to provide all MIT students with membership in the Boston Museum of Fine Arts. Another grant to four students and staff members of the Architecture Machine group supported the development and maintenance of innovative and highly visual software for a new computer installation at the Boston Children's Museum. A collaborative project with the Joffrey Ballet Company supported two graduate students in preliminary work toward the design of an interactive theatre set which responds visually to the movements of a dancer.

Since the Grants Program was formally launched in 1974, just over $280,000 has been expended to support 159 projects, generating an additional $285,000 in matching gifts. Council grants range from seed money for experimental projects and support of performances to research, purchase of equipment and services, and collaborative projects among several groups.

Publications

In addition to materials generated for the Arts and Media Technology Facility (including revised case statements, a photographic notebook, and a slide show with accompanying text cards), the Council continued to publish its monthly calendar of events and semiannual Newsletter. At year's end the Executive Committee decided to merge these publications into a composite piece which will include a monthly calendar as well as articles describing Council and MIT activities in the arts. This will be circulated to all Council members, to MIT alumni of the Departments of Architecture and Humanities, to MIT faculty and administrators, and to local community organizations.

Special Events

Special events this year were concentrated in the New York area, and involved Council members and non-Council donors, MIT alumni, and representatives from local and national foundations, corporations, and arts institutions.

On May 19 Professor Barry Vercoe and the Experimental Music Studio presented a program of computer-generated music composed during annual summer workshops in computer synthesis and computer music composition. This concert, held in Alice Tully Hall at Lincoln Center, is believed to have been the first full-length professional presentation of electronic music ever held in New York City. It attracted coverage from publications including The New York Times, the Village Voice, and The New Yorker. Following the concert Council members and guests convened with Dr. Wiesner at the home of Council member Eugene Schnell and his wife to meet some of the musicians and to view the Schnell's pre-Colombian art collection.

On June 24 Council members and guests joined New York area MIT alumni at the Metropolitan Museum of Art in celebration of "For Spirits and Kings," an exhibition of African art from the collection of Paul and Ruth Tishman. The reception and special viewing honored Paul Tishman, a founder and key supporter of the Council. Chairman of the Corporation Howard W. Johnson was on hand to greet the 200 guests.
Academic Liaison Program

In addition to staff participation in several arts committees and assistance with policy and program development, the Council provided diverse services to MIT's artistic community. The new membership program was launched with a tour of the collection followed by a reception for MIT students at the Boston Museum of Fine Arts. A well-attended evening seminar featured national and state arts officials who provided artists and arts administrators from MIT and the surrounding community with up-to-date information concerning reduced arts budgets and major program changes.

During the Independent Activities Period, over 40 students, staff, faculty, and Council members attended the Council's two-week seminar entitled "Support Structures for Individual Artists." Conducted by Associate Director Deborah Hoover, the course was designed to help artists gain a broader understanding of corporate, foundation, and government support. Guest speakers included: Dr. Harriet Ritvo of MIT's Writing Program; Perrin Ireland of the National Endowment for the Arts; Barbara Baker of the Cambridge Arts Council; Sidney Briem of the Artists Foundation; Samuel Yanes, director of Corporate Communications at Polaroid Corporation; Michael A. d'Amelio, vice president of the Business Committee for the Arts; and Kent Davy, Esq., of Milliban, Tweed, Hadley & Melloy, a major New York law firm. During the two-week period participants were encouraged to locate funding sources for a particular project, write a proposal, and deal directly with the appropriate officials. By the end of the class one participant had already secured a sizable summer research fellowship.

The Acquisitions Committee, chaired by Ida Rubin, continued to provide valuable assistance to the faculty Committee on the Visual Arts (CVA), particularly advice on new acquisitions for the CVA's two student loan programs and on problems of maintenance and conservation of the MIT permanent collection.

Two awards of $500 each were made to individual artists at MIT for achievement in the creative and performing arts. The Jerome B. and Laya Wiesner Art Awards were established by the Council in 1979 to honor the Wiesners for their contributions to the arts at MIT. The awards are not limited to individuals but also may be given to living groups, organizations, and activities which have contributed significantly to the MIT community through the arts. This year 12 nominations for the awards were judged by a committee appointed from the five Schools. At a ceremony on Convocation Day, May 11, Dr. and Mrs. Wiesner presented awards to Ronald C. Tyler for his contributions to the dramatic arts at the Institute, especially Spanish theatre, and to Judith Black for achievements in documentary photography, in particular her exhibition at the MIT Creative Photography Laboratory entitled "Mothers/Photographers."

Staff Transitions

Roy Lamson, Class of 1922 Professor, Emeritus, who had stayed on for a transitional year as Special Assistant to the President for the Arts at President Gray's request, stepped down from the position he has held in guiding the Council from its inception in 1971. Professor William L. Porter, who concludes his leadership as Dean of the School of Architecture and Planning in September, has been appointed as Professor Lamson's successor. Professor Lamson has now been appointed Secretary of the Council. Professor Porter will serve as liaison between the Council and MIT faculty and provide overall direction for the Council staff, headed by Peter Spackman as Executive Director. Associate Director Deborah A. Hoover was promoted during the year to the position of Deputy Director, with responsibilities for Council fundraising, the Grants Program, and academic liaison. In September, the Council's former Associate Director, Elsa G. Sonnabend, resigned her position at MIT to take a post in development at Brandeis University; in December Elizabeth C. Scott joined the Council staff as Associate Director. Ms. Scott comes to MIT from the development office at Smith College, where she coordinated project grants and government relations. Susan Arthur, who worked as an intern for the Council during the fall and winter, became a part-time office assistant during the spring. David Bromley became the Council's secretary after the resignation of Sandra Congleton early in the year.

PETER SPACKMAN
DEBORAH A. HOOVER
Vice President, Financial Operations

The financial operations of the Institute were in balance between income and expenses for the fifth consecutive year, which is no small achievement in view of the high inflation rates during this period. Inflation continues to be a relentless driving force on the expense side of the ledger without a compensating effect on the income side, despite intensive efforts to increase the gift stream to the Institute. Even with all the difficulties, however, it gives us some satisfaction to report a small surplus balance for fiscal year 1981, and this is after providing funds through operations for additions to the educational plant. Another small but significant step was taken in the past fiscal year with the addition of several portions of unrestricted bequests to general endowment.

The need for current funds to maintain operations continues to dominate the scene, but the fundamental requirement for endowment funds for the capital base should not be neglected. Keeping up the purchasing power of that endowment is presenting a problem that we simply have not yet been able to solve.

There continues to be a considerable amount of publicity with respect to the Federal Office of Management and Budget Circular A-21, which states the cost principles under which colleges and universities are reimbursed for their sponsored research expenses. The principal issue relates to new requirements for faculty effort reporting. The year just ended completes our first year of operations under the revised Circular, and we can report that no major problems have surfaced at MIT. However, there is need for clarification and refinement on some issues, and MIT has joined with her sister institutions to bring about the necessary changes. The turmoil which exists in some quarters is preventing the return of a healthy partnership between the Federal government and the university community, and existing differences should be settled. The prospects for resolution in the fall of 1981 appear to be quite good.

Sponsored research continues to flourish with a few setbacks here and there, but nothing of serious proportions. Continued Federal support for research should remain strong. In addition, an interesting and rewarding area of activity during the past year, and one that continues into the present year, is a renewed interest on the part of industry for the support of sponsored research which brings about a need for new and creative instruments for carrying out that research.

A report on the establishment of an Office of Student Financial Services follows in this section of the report. Suffice it to say here that this is the result of an organizational change which was given long and serious thought. Its new location, in the Office of the Vice President for Financial Operations, reflects the financial nature of the operation itself, as well as the recognition that one of its greatest needs is the acquisition of capital, along with current funding for scholarships, fellowships, and loans. The intentions of the Federal government to gradually reduce the relative amount of funding for student support adds further complexities to an already difficult situation. The Institute is working on many fronts to solve this problem.

STUART H. COWEN
Office of the Comptroller

During fiscal year 1981, the major effort begun in January 1980 continued with the development of a new integrated payroll system. Progress has been slower than anticipated, due primarily to the necessity of creating a development environment consistent with current-day technology, i.e. on-line interactive. In addition, the project has had significant turnover of systems and programming personnel. Current scheduling calls for implementation of the Service Staff Payroll in September 1981, followed by the Weekly Payroll (Support Staff) in October 1981. The Student/Voucher and Staff payrolls will be implemented during the balance of fiscal year 1982.

During the fiscal year 1981, computerization of the Sponsored Billing System was completed. The Lincoln Laboratory Fiscal Office completed integration of its automated accounting system which provides a data base for the information system put in place. Work is continuing to expand in both the data base and information system areas, including evaluation of manual and machine systems and newer available hardware.

The Audit Division continued its task of verifying the implementation of management policy and procedure, the maintenance of internal controls, and the safeguarding of assets. Financial audits were conducted in those departments which produce individual revenue. The audit of federally funded student aid programs (with the exception of the Guaranteed Student Loan Program) was completed for the two-year period ending June 30, 1980, as required by the US Office of Education. The audit report contained no financial exceptions. Reported areas of non-compliance were minor, and they have been or are in the process of being corrected. In calendar year 1981, the Electronic Data Processing (EDP) Audit Section concentrated its effort on recently installed systems (notably in student-related areas) and special requests. Recently installed systems were tested for reliability and completeness. Special requests included the review of standards and procedures for data processing at the Lincoln Laboratory Fiscal Office and the review of the Administrative Data Processing Tape/Disk Library. The Audit Division has been reorganized to integrate two previously separate audit staff groupings (general audit and EDP audit) into one consolidated organizational group, capable of performing full-range audits in EDP and traditional financial environments. We expect to achieve a greater degree of efficiency in the deployment of the revised staff, and anticipate an increase in the cohesiveness of the group collectively by broadening the horizons of each member to include full-scope audit assignments.

PERSONNEL CHANGES

There were several staff changes during the past year. In September 1980, Philip M. McMahon was appointed senior accounting officer, and John F. McKenzie and Elizabeth C. Nelligan were appointed senior staff accountants. In December 1980, Jane H. Powers was appointed staff accountant, and Frederick I. Crowley was promoted to senior accounting officer for payrolls, replacing Joseph R. Cullinan who was promoted to assistant to the comptroller for special studies. In January 1981, Andrew J. Brown was promoted to senior staff accountant, and Kenneth M. Arsenault, Paul J. Arsenault, Jill E. Bollin, Marie Dolloff, Eleanor C. Forsberg, John J. Ford, Jr., Carol J. Gleason, Joseph B. Paiva, Jr., and Diane E. Tenen were appointed staff accountants. In March 1981, James F. Brady joined the Comptroller's Office staff in the capacity of accounting officer. In April 1981, Francis T. Conroy and James H. Dreyer joined the Comptroller's Office staff in the capacity of assistant auditors. In May 1981, Maureen J. Nelligan joined the Comptroller's Office staff in the capacity of assistant auditor. In June 1981, Joseph J. Casarano, Jr., was promoted to director of Internal Audit, replacing Edward L. McCormack who retired after having served as director of Internal Audit for 25 years.

PHILIP J. KEohan
Office of Sponsored Programs

For fiscal year 1981, the total volume of sponsored research performed on campus is expected to approximate $183,970,000, an increase of 12.8 percent over fiscal year 1980's volume of $163,122,000.

As shown in the following tabulation, on-campus research supported by the National Science Foundation and the Departments of Defense and Health and Human Services experienced growth in real terms, while Department of Energy support declined after a period of rapid increase. As in 1980, however, the most dramatic gain was in research supported by industry.

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<tr>
<td>Department of Defense (DOD)</td>
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<td>13,694</td>
<td>15,223</td>
<td>19,183</td>
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<td>Department of Energy (DOE)</td>
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<td>32,338</td>
<td>42,005</td>
<td>50,004</td>
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<td>Department of Health and Human Services (formerly DHEW)</td>
<td>7,843</td>
<td>18,855</td>
<td>22,061</td>
<td>25,320</td>
<td>29,175</td>
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<tr>
<td>National Aeronautics and Space Administration (NASA)</td>
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<td>8,064</td>
<td>9,505</td>
<td>9,295</td>
<td>10,525</td>
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<td>National Science Foundation (NSF)</td>
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<td>21,832</td>
<td>23,469</td>
<td>25,055</td>
<td>29,913</td>
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<tr>
<td>Other Federal Sponsors</td>
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<td>7,363</td>
<td>8,727</td>
<td>9,554</td>
<td>10,211</td>
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<td>Total Federal Sponsorship</td>
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<td>120,990</td>
<td>138,411</td>
<td>152,397</td>
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<tr>
<td>Industry</td>
<td>2,148</td>
<td>6,745</td>
<td>8,151</td>
<td>13,058</td>
<td>17,164</td>
</tr>
<tr>
<td>Foundations and Other Nonprofits</td>
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<td>7,917</td>
<td>9,538</td>
<td>9,654</td>
<td>11,614</td>
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<tr>
<td>Other</td>
<td>598</td>
<td>2,466</td>
<td>2,627</td>
<td>1,999</td>
<td>2,795</td>
</tr>
<tr>
<td>Total Non-Federal</td>
<td>5,905</td>
<td>17,128</td>
<td>20,316</td>
<td>24,711</td>
<td>31,573</td>
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<tr>
<td>Total Research Volume</td>
<td>55,838</td>
<td>119,274</td>
<td>141,306</td>
<td>163,122</td>
<td>183,970</td>
</tr>
</tbody>
</table>

MAJOR DEVELOPMENTS

In fiscal year 1981, as in other years, the administration of sponsored programs was significantly affected by external events, four of which typify their variety:

Office of Management and Budget (OMB) Circular A-21

Revisions to OMB Circular A-21, the Federal cost principles for educational institutions, which had been the subject of negotiations between universities and the Federal government for nearly
five years, were issued in fiscal year 1979; but their interpretation and application to MIT required a major continuing effort during 1981. In January, initial MIT guidelines were issued for the conversion of sponsored research projects from a salary and wage base for collection of indirect costs to a modified total direct base. The conversion will be effective July 1, 1982, and substantial effort must still be devoted to refining those guidelines and solving problems resulting from their impact on specific programs.

During the same period, national controversy over the new A-21 requirement for reporting 100 percent of faculty effort continued unabated and is not yet resolved. Under consideration at year’s end were a variety of proposals by the Council on Governmental Relations, the Association of American Universities, the Department of Health and Human Services, the Office of Management and Budget, and representatives of various professional and learned societies.

Export Controls

In fiscal year 1981, the issues involved in applying export restrictions to teaching and research activities conducted by American universities received national attention after the presidents of Stanford University, California Institute of Technology, MIT, Cornell University, and the University of California wrote to the Secretaries of Commerce, State, and Defense in February expressing deep concern about attempts to apply to universities the International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations (EAR), administered by the State and Commerce Departments, respectively. As an example, they cited efforts to restrict publication of unclassified university research results arising from DOD-sponsored projects such as the Very High Speed Integrated Circuit (VHSIC) program. At year’s end, the agencies had not yet responded, although a reply from the Department of State with respect to application of the ITAR appeared imminent. In addition to the emerging controversy over application of controls to microelectronics programs and to a list of critical military technology being developed by DOD, the debate continued over the application of the ITAR to cryptographic research at MIT and other universities.

The Whitehead Institute

Following a series of discussions conducted during the spring, it was announced at the close of the fiscal year that MIT and Edwin C. Whitehead, founder of the Technicon Corporation of Tarrytown, N.Y., had tentatively agreed that MIT would collaborate with a life sciences institute that Mr. Whitehead plans to establish in the Kendall Square section of Cambridge.

Plans are now being formulated for construction of the Whitehead Institute Building on Main Street, opposite the MIT East Garage. The annual income of the new institute will be $5 million, supplemented by research grants.

The Whitehead Institute for Biomedical Research will focus on basic questions in developmental biology. The tentative agreement with MIT calls for the Director to be an Institute faculty member, and for MIT members to constitute a minority of the new Institute’s Board of Directors. The Institute would have a faculty of about 20 members, most or all of whom would also be appointed as faculty members of MIT, initially in the Department of Biology. In addition, the Whitehead Institute would support additional graduate students at MIT whose presence would be made possible by the expanded faculty.

The Federal Research Budget

The most traumatic events of fiscal year 1981 in terms of impact on specific MIT research programs were the budget rescissions and cutbacks triggered by the change in Federal Administration and in the composition and control of Congress. Although MIT narrowly escaped the impact of unanticipated rescissions in a number of major DOE programs, the elimination or severe cutback of several programs at the Energy Laboratory and the National Magnet Laboratory in fiscal year 1982 appears almost certain. Other major programs, such as the Sea Grant Program, are also targeted for reduction, and the future of Federal research support for the humanities, social sciences, science education, and for fellowships and student financial aid, looks bleak.
Office of Student Financial Services

PERSONNEL CHANGES

During the year the following staff changes occurred in the Office of Sponsored Programs:
Effective July 1, 1980, Francis T. Conroy, assistant director, OSP transferred to the Department of Purchasing and Stores as Subcontract Administrator. On February 1, 1981, Heather D. Kraemer, administrative assistant in the Department of Materials Science and Engineering, transferred to OSP as an assistant contract administrator. On February 16, 1981, Steven D. Goode transferred from the Office of Facilities Management Systems to OSP as an assistant contract administrator, and Martha L. Newton joined OSP as an assistant contract administrator, having previously worked at the National Science Foundation as a professional assistant in the Experimental Program to Stimulate Competitive Research.

GEORGE H. DUMMER

Student Financial Services

The Office of Student Financial Services was established October 1, 1980, linking the Student Accounts Office, the Office of Student Financial Aid, and the Student Loan Office. For several years these offices had experienced a high degree of operational overlap and interface, since most students dealt with all three. The closer linkage provides students the benefit of integrated operational policies, procedures, and schedules; promotes operational efficiency through common access to data systems; encourages cooperative research into problem areas and policy matters; and makes possible effective and rapid implementation of needed improvement.

Thereafter, it quickly became apparent that these goals could be realized even more effectively with the establishment of a single office to which both the Student Account and Loan Offices would report. Hence, on May 16, 1981, the Bursar's Office was reestablished for that purpose.

The essential character and mission of these organizational units remain unchanged. Each will continue to respond to our parallel concerns for student service and sound management of its student-related financial resources. Separate reports from the Student Financial Aid Office and the Bursar's Office follow below.

Staff Notes

Jack H. Frailey, who had been director of the Financial Aid Office, became director of the Office of Student Financial Services. Leonard V. Gallagher, who had been associate director and executive officer of Financial Aid, was made director of Financial Aid.

Arthur R. Wagman left his position as assistant superintendent of schools for business administration in Wayland, Massachusetts, to become the new Bursar. John R. Rogers, who had been MIT's student loan officer, became associate bursar and executive officer. James F. Brady, who had been accounting officer for Student Accounts, transferred to the Comptroller's Accounting Office to manage the travel section.

STUDENT FINANCIAL AID OFFICE

Another record increase in tuition rate set the stage for large increases in the need for financial aid in fiscal year 1981. The Federal government was again a principal "donor" of aid -- providing grants, loans, and funds for student wages. But unlike the trend set in earlier years, the government's role entered a transition phase in 1981, with all programs leveling off and some being cut back slightly, echoing the Carter administration's late-arriving caution in spending for higher education. And the fiscal year ended in a pall of gloom, as severe cuts in financial aid
programs seem inevitable for the coming years. Never has our growing dependence upon Federal aid been felt so keenly, as the prospects of its withdrawal grow upon us.

Grant Programs

No sooner had the Federal government opened the gates to the Basic Grant Program, to include students from middle-income families (see the 1980 report) than the cost of this Program began to be troublesome, and rescission of part of the fiscal year's appropriation caused a reduction in the amount of Basic Grants received by MIT students. This item dropped from $977,000 last year to $920,000 in fiscal year 1981. The Supplemental Grants Program, having been forward-funded by Congress a year ago, remained unaffected, and the Institute again enjoyed the use of $1,140,000 from this program. ROTC Scholarships continued to increase as tuition rose, and these programs provided $2,497,000 in awards, $470,000 of which went to students who demonstrated need. The endowment for scholarships and grants increased by $1,049,000, and the total endowment income provided $2,640,000 for grants. The planned use of supplementary unrestricted funds to augment the grant program reached a new high of $1,455,000. Modest increases in outside-agency awards ($990,000) and in gifts to MIT for current use in the scholarship program ($476,000) rounded out the grant program. In addition, another $679,000 in outside scholarship awards were received by students without respect to need.

Loan Programs

The Institute again made good use of its growing National Direct Student Loan Fund, with nearly every needy US undergraduate citizen receiving a loan from this source. In addition, nearly half of all undergraduates (both those with formally-defined need and those without) availed themselves of the opportunity to borrow under the Guaranteed Student Loan Program (GSLP). Indeed, when graduate borrowing under the GSLP is included, this program became the largest single source of financial aid last year, accounting for over $10,000,000 of expense money in the hands of MIT students. Strong indications at the close of the fiscal year are that the GSLP will be severely curtailed, and will become available only to needy students whose other financial aid is inadequate. The Technology Loan Fund lent less than $800,000 in 1980-81, the lowest annual borrowing from that source in over 15 years. Loans were made chiefly to international students who are not eligible for Federal loan programs.

Student Employment and The College Work Study Program

The continued widespread availability of Guaranteed Loans has affected total on-campus earnings of needy undergraduate students again this year. The number of students working has remained the same, but total earnings by needy students have not risen even by the amount of our on-campus minimum wage. This indicates a continuation of the trend noticed last year toward increased indebtedness.

The College Work-Study Program was cut by 10 percent for fiscal year 1981. The grant was used to support off-campus work in public and nonprofit organizations and to subsidize student employment at the Institute. Undergraduates received 60 percent of the total grant and graduate students 40 percent.

Staff Notes

Yvonne L. Gittens joined the counseling staff as assistant director, and Jane D. Smith left the Registrar's Office to accept appointment as assistant director and data-processing manager.

THE BURSAR'S OFFICE

Students were billed for the year in excess of $70 million for tuition, dining, dormitory, insurance, and other miscellaneous fees. Student loan notes receivable amounted to $30.8 million at the close
Office of the Director of Finance

of the fiscal year, an increase of 2.7 percent. These notes are funded by $8,470,000 of MIT Loan Funds established by friends and alumni of the Institute, $15,830,000 of Federal funds in support of the National Direct Student Loan (NDSL) program, $400,000 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, $3,100,000 from a local bank, and $800,000 from Institute investments.

Staff Notes

A large number of organizational and titular changes have been made as a result of the reestablishment of the Bursar's Office. Three assistant bursars were named to lead the loan collection, systems integration and control, and student accounts sections. They are, respectively, Anne S. McCormick, who had been loan collection officer, John F. O'Brien, who had been senior staff accountant, and Richard E. Davidson, a new employee, who had been the elementary school assistant principal in Amherst, Massachusetts. Appointed assistants to the bursar were Maureen C. DeCourcey, office manager for Student Loans; Paul L. Bergonzi, Systems Control and Accounting; and Student Account Representatives Eleanor B. Smalley for freshmen and sophomores, Ann W. Chick for juniors and seniors, Joanne C. Barrett for graduate students in the School of Engineering, and Maurice L. Linton for graduate students in the Schools of Architecture, Humanities, Management, and Science. Mr. Linton, a new employee who replaced James F. McTigue upon his leaving the Institute, had held several responsible positions in the administration of the government of Guyana.

JACK H. FRAILEY

Office of the Director of Finance

Fiscal year 1981 is the fifth consecutive year that MIT has been in essential fiscal balance. As we planned for fiscal year 1981, it became clear that the effect of inflation could not be denied and that substantial increases in budgets for salaries and expenses would be required. The 1981 tuition rate (which was decided in January of 1980) was increased by 17 percent, the largest increase in MIT's history. A portion of this increase, about one-third, was intended to offset the too-small tuition increase for fiscal 1980, when we seriously underestimated the inflation rate.

The initial budget for the year anticipated a deficit of $1.7 million. Fortunately, several occurrences during the year reversed the earlier projections, and the year ended with a modest surplus of $164,000. Important among these changes were an increase in graduate student enrollment of almost 300 students over the initial budget forecast, the availability of additional current funds in support of the budget, increasing research volume, and continued strength in the short-term money market -- resulting in more investment income.

Funds available from operations also contributed significantly to acquisitions from the investment portfolio of real estate for educational plant which is necessary to accommodate the growing need for space for both the instruction and research activities. In addition, $462,000 of unrestricted gifts, grants, and bequests was added to endowed funds.

The book value of educational plant increased by $32,170,000 to $262,658,000 at June 30, 1981. This increase represents the largest construction volume done in one year at the Institute in the last decade.

The new athletics center was completed in the fall and was used for the first time for the Inaugural luncheon. Work on the new Whitaker College of Health Sciences, Technology, and Management/Health Services Building on Carleton Street and the new dormitory for undergraduates at 500 Memorial Drive continued. Completion for all three buildings is scheduled for the first half of fiscal year 1981-82.

Major renovation work continued on the buildings at 70 Memorial Drive and at One Amherst Street with completion scheduled for early fiscal year 1981-82. Major renovation projects completed during
the year include the George Harrison Spectroscopy Laboratory, the Aga Khan Islamic Architecture facility, a portion of the Department of Architecture, and major renovations to the Plasma Fusion Center at 167 Albany Street.

The construction of these projects was made possible by the generous support of Institute donors and Federal sponsorship of research programs. A bond issue sold in fiscal year 1979-80 rounds out the financing plan for these facilities.

The development of the new budget system continued throughout the year, and it is anticipated that it will be tested and completed in the next few months.

The Student Accounts Office and the Student Loan Office were transferred in October to a newly created Office of Student Financial Services. This change, which is reported on in a separate section, is a positive move in improving the servicing of student accounts.

It is with sadness that the death of Nicholas R. Ruggiero, a budget officer in the Fiscal Planning and Budget Office for the last two years, must be recorded. His contributions to the Institute and his winning way will be missed.

William J. Coady was transferred from the Audit Division to the Budget Office as Mr. Ruggiero's replacement. Mr. Coady's background in data processing techniques and applications should be invaluable as the new budget system is implemented.

JOHN A. CURRIE
Vice President, Operations

This past year was one of intense activity in the area of new construction and major facilities renewal. The Athletics/Special Events Center was completed in the fall, and it was quite fitting that the first event to be held there was the inaugural luncheon for President Paul E. Gray. Excellent progress was made during the year on the undergraduate dormitory at 500 Memorial Drive; the Whitaker College of Health Sciences, Technology, and Management/Health Services complex; One Amherst Street; and 70 Memorial Drive. However, strikes by masons and carpenters may adversely affect previously anticipated completion dates.

The new dining program recommended by the Committee on Campus Dining was implemented this year. Now that most of the short-term goals outlined by the Committee have been achieved, longer-term problems such as the upgrading of food service facilities at Walker Memorial are being attacked. The ultimate success of the overall program rests heavily on the satisfactory resolution of these issues.

It has become increasingly evident that in the years ahead the Institute will face the challenge of an ever-increasing demand for academic, research, and residential facilities at a time when existing space, future building sites, and financial resources are severely limited. This situation will be further exacerbated by pressures exerted by local government to control our expansion.

On a more positive note, I believe the reports which follow will show that MIT is adequately prepared to face these challenges.

WILLIAM R. DICKSON

Campus Police

Campus Police provided around-the-clock service during the year, including police patrol, emergency medical service, investigative service, and the more routine tasks involving lockouts, escorts, parking, and traffic control.

The total number of complaints during the year was 1,933. This figure represents a decrease of 318 from the previous year. There were 39 crimes against persons, with assault and battery the most common. One rape was reported.

Larceny continues to be the most frequent crime on campus, although the property loss has decreased markedly from $72,012 in 1979 to $44,418 in 1980. Of this amount, property valued at $13,875 was recovered by the patrol. The sharp curtailment in this crime category is considered to be a direct result of the efforts of the patrol's crime prevention program, which has increased community awareness and encouraged individuals to practice preventive measures in order to safeguard their personal property and that of the Institute.

Automobile thefts experienced a sharp decline from 77 in 1979 to 37 this year. This total represents the lowest number of motor vehicle thefts from the MIT campus for the past 10 years. Again, the improvement is attributed to the extensive educational programs conducted on crime prevention in which emphasis is placed on automobile theft protection.

The Institute ambulance and the 24 Campus Police officers trained as Emergency Medical Technicians responded to 1,776 calls for assistance during the year. This represents a slight increase over
Vice President, Operations

the previous year. Routine transfers between the Medical Department, the Infirmary, and area hospitals are included in this total as are emergency responses to the MIT community.

A substantial increase in the number of requests for escort service was recorded during the year, as the total reached 8,862 -- up from 5,012 the previous year. Due to the ever-increasing demand for this service and its value as a crime prevention measure, the Campus Police plan to acquire an additional motor vehicle to be used exclusively for this purpose.

JAMES OLIVIERI

Endicott House

Use of the Endicott House this year appears to be much the same as in the prior year. However, this was due largely to a tremendous increase in business in May and June, when a total of 11 resident groups held conferences here. The house was closed for one month during the summer to work on capital improvements, and was used only three nights by resident groups during December and January.

The house was used 278 days and 185 nights during the year. A total of 34 resident conferences were held. Of these, 23 were MIT groups, whose guests accounted for 4,352 overnights; 11 were non-MIT groups, accounting for 526 overnights. The total overnights, 4,878, averaged 26.3 guests per night of operation.

Non-resident use of the house remained approximately the same as the prior year. There were 117 non-resident groups with a total of 8,578 guests. Of these, 86 were MIT-affiliated with guests totaling 6,942; 31 were non-MIT groups, whose guests totaled 1,636.

During the year, 22,563 meals were served, an average of 81.1 meals per days of operation.

AIMEE PIERSO

Graphic Arts and Audio Visual Services

Work order volume and gross revenue continued to increase in all departments. The revenue increase of five percent was lower than in previous years, due largely to a moratorium on price increases at Graphic Arts Service for the past one and a half years. Total revenue was approximately $3.6 million.

New equipment included a Profit Control Maxi Manager Computer System, designed to improve our statistical, financial, and record-keeping procedures. At present, it is being used for job costing, perpetual inventory, and various analyses. Plans are under way to include offset job estimating as an additional function.

Copy Center growth was restricted due to space limitations. The department looks forward to new and larger quarters for both the Building E52 and Building 3 locations in the coming year.

The Audio-Visual section continues to be involved in updating sound and projection equipment at various Institute locations while providing an ongoing service to the Institute.

JAMES W. COLEMAN
Housing and Food Services

This year's freshmen were the first participants in the new dining program initiated this past fall. The implementation of this plan, as proposed by the Committee on Campus Dining, has proceeded "on schedule" with no major problems. The acceptance of the use of the control system, the efforts of the House Commons Committees and the Dining Advisory Board, and the support and efforts of the students and employees contributed to a high level of success. The system and services are continually being reviewed, and with the assistance of the Dining Advisory Board, several positive changes have been made in the program.

Several food service-related studies were initiated during the year. Arthur D. Little, Inc. was requested to conduct an overview evaluation of Food Services' operations. Their conclusions and recommendations were very helpful in the overall implementation of the Dining Program.

Dober and Associates, Inc. has been retained to conduct a market survey of the employee and graduate student population. The purpose of this survey is to evaluate the facilities and services of the existing food delivery operations on and near the campus, and to establish food preferences and potential usage of additional and/or different types of services for the future. The data is currently being processed and the report should be complete early next year.

The architectural firm of Goody, Clancy and Associates, Inc. has been selected to study the facilities at Walker Memorial, specifically those relating to dining. The purpose of this study is to define a means of providing separate dining facilities for the students on the east side of the campus, which would allow them to conduct dining-related programs without being infringed upon by the rest of the community using the a la carte system. A preliminary report is due early next year.

The dining services in McCormick Hall were reopened this year after being closed since 1972. This opening, the installation of the computer control system for commons, and the filling of several long-time vacant positions required several additions to the staff.

The construction of the new 352-bed dormitory at 500 Memorial Drive continues on schedule; however, contingency plans for late August 1981 occupancy are being made should the construction schedule slip because of existing labor problems.

A major maintenance program to maintain the integrity of the physical plant and upgrade the quality of the residential facilities has continued throughout the year. Major projects completed include new energy-saving windows in East Campus and Senior House, construction of a community kitchen in Baker House, upgrading of the kitchen facilities in the suites of Burton-Conner, and facility changes to the central office area. Numerous smaller projects, including renovation and upgrading of student activity facilities, were also completed in several residences.

This year has been extremely busy with planning for the new residence and implementation of the dining program. The department members have all responded to these tasks and deserve special recognition.

HARMON E. BRAMMER
Office of Facilities Management Systems

Facilities Management

The Office of Facilities Management Systems (OFMS) is responsible for the collection, maintenance, and reporting of data for more than 22,500 individual spaces at MIT, comprising 7.8 million net usable square feet. Using the newly regenerated INSITE 3 Program, an MIT-developed space accounting system, two major updates to the space inventory were completed. Each update was followed by the distribution of several reports to academic and administrative officers, as well as numerous special reports produced throughout the year. Also, historical facilities data continued to be maintained in graphic and statistical form.

Two significant additions to the facilities inventory activities in OFMS were made this year. The first was the transfer of responsibilities for the maintenance and production of MIT’s scaled floor plans. The second encompassed the maintenance of the room numbering scheme for all existing and new facilities whenever individual spaces undergo physical changes. The net effect of these activities will be to increase the timeliness of graphically recording space changes and to reduce data transfer errors or omissions.

INSITE Consortium

Another major responsibility of OFMS is to provide support to the existing consortium of external users of the INSITE technology, as well as to foster the continued growth of the consortium in both its membership and the quality of its facilities management. This past year saw four new members of the Consortium, bringing the membership to 30: the Commonwealth of Massachusetts, Texas Tech University Health Sciences Center, Sidney Farber Cancer Institute, and Exxon Research and Engineering Company. Each organization employs the INSITE system and its associated methodology both to manage their inventories of building space as well as to share their knowledge and experience in this area with MIT.

Support activities peaked during the year in the form of telephone contact from members, visits by departmental staff to members' sites, the conducting of training courses, and publication of a quarterly newsletter.

Computer Support

Of significant and exceptional effort this past year was the systems support of INSITE 3 for MIT and the Consortium. Included in that effort was the design, programming, and testing of required INSITE 3 enhancements, and the support of other systems and data input needs in the property management area. Planning for INSITE 4 also began in order to assure a continuity for MIT’s facilities management needs.

Property Management

During the year, more than 4,500 newly acquired items of movable equipment were identified and tagged with bar code labels. An inventory of existing items of movable equipment was begun, and approximately 21,000 items were identified and appraised. Nearly 400 final inventories and financial reports pertaining to contracts and grants were prepared.

Our program to acquire excess government equipment was broadened when almost $3.2 million (original acquisition cost) of excess government equipment was acquired. In addition, over $270,000 of equipment was acquired from the State Surplus Warehouse in Taunton, MA. Also, items of equipment as well as materials were acquired from the National Association for the Exchange of Industrial Resources.
Roughly $350,000 worth of equipment was transferred from one MIT department to another for reutilization. Equipment which was unneeded by the MIT community was sold. These sales totaled almost $70,000. Most of the equipment available for reutilization or sale continued to be displayed at the MIT Equipment Exchange.

In conjunction with the Society for Property Administrators, the office was responsible for presenting a two-day Property Management Seminar in Washington, DC, with over 200 in attendance from across the country and Canada. Speakers included members of the OFMS staff as well as speakers from other universities and various government agencies.

Storage Facility
The operation of the MIT storage facility at 224 Albany Street continued, providing storage to 46 departments on a six-month cycle for the temporary storage needs of the Institute community. Through the building users' group, tighter security control of the building was accomplished.

Silver Recovery
An Institute-wide program for the electrolytic recovery of silver from photographic solutions was implemented. The program promises financial reward to all who participate.

KREON L. CYROS

Physical Plant Department

Utilities and Engineering
The Institute's energy conservation program demonstrated its benefits during the past year in the face of the most severe weather conditions of the last decade, the hottest summer followed by the coldest winter. A reduction of roughly 40 percent in energy consumption during fiscal year 1980-81 from our base year (1973) consumption level resulted in a cost avoidance of over $5.5 million. Our actual energy costs were $10 million at the central plant and $12 million overall, including off-campus sites.

During the year, we continued to experience the same abrupt increases in fuel oil prices, with the Institute's oil cost reaching a high in February of $40.80 per barrel. The global oil glut caused this price to drop to $33 per barrel in spring and early summer, and although oil is not burned during the summer months, this price reduction is beneficial to MIT because the natural gas price is pegged to it. Our records show a composite fuel price increase of 30 percent during the year and an increase of over 100 percent in the last two years.

The Building Energy Audit and Modification (BEAM) Program, which is intended to provide for more energy-efficient operation of the heating, ventilation, and air conditioning systems in campus buildings, resulted in the initiation of systems modifications projects in four buildings with an estimated cost in excess of $1 million. Two of MIT's most energy-intensive buildings, the Dreyfus and Bush buildings, were also included in the project. Engineering plans are nearly complete for an additional two projects and an energy audit has been completed on a third. It is expected that modifications with a projected two-year payback period in our energy-intensive buildings will result in further significant reductions in total energy consumption.

The new East Campus Chilled Water Plant, located in the basement level of the recently renovated building at One Amherst Street, went into operation in June. This 3,000 ton plant, with extensive distribution mains, will serve existing buildings and new construction on the east campus and permit the retirement of chillers in the Hermann and Sloan buildings. In addition, chilled water mains were extended across Massachusetts Avenue from the Main Campus Chilled Water Plant to serve the new Athletics Center, the Julius A. Stratton Student Center, and Kresge Auditorium. The older chiller units for the latter two buildings were retired from service.
The planning process to meet the forecasted need for additional central steam capacity in the mid-1980s, with possible cogeneration capability, has occupied a steering group this year, including physical plant engineers and an academic support group. At year end, an engineering consultant was selected to make a feasibility study of the proposed plan including alternative fuels, environmental considerations, and financial impact.

Architecture, Engineering, and Construction

During the year, construction continued at its highest level since the major facilities expansion of the 1960-1970 decade. The Athletics facility was completed in September in time for the inauguration luncheon to be held in its field house. The 500 Memorial Drive dormitory; the Whitaker College of Health Sciences, Technology, and Management/Health Services complex; 70 Memorial Drive (Program in Science, Technology, and Society/Sloan School); and One Amherst Street (Energy Laboratory and Sloan School) are all scheduled to be completed in the summer and fall of 1981.

Other renovation projects completed during the year were the Harrison Spectroscopy Laboratory in Building 6, an addition to the Plasma Fusion Center in NW16, the Aga Khan Islamic Architecture facility in Building 10, and major space for the Department of Architecture in the former Epsco Building on Massachusetts Avenue at the north side of the campus.

Major projects in the design stage were the EG&G (Edgerton, Germeshausen & Grier) Education Center (a five-story building to be connected to the Fairchild Building link), the Arts and Media Building, intended for a site on Ames Street next to the Seeley G. Mudd Building, and a new 24-bed residence and conference facility at Endicott House in Dedham, MA. Large renovation projects in design include the Sloan Building, where the first phase of its rehabilitation is being planned for three floors, and the infirmary building on Memorial Drive, which will be converted to a graduate women's dormitory.

Projects in the preliminary stages include the Plasma Fusion Center Tandem Mirror Project in the Nabisco Building on Albany Street, a Very Large Size Integrated Circuits (VLSI) research facility, and a new physics building.

Building Operations and Support Services

The support services group was responsible for the organization of services for several major Institute events including President Gray's inauguration and the third outdoor commencement held in Killian Court. Initial use of the new Athletics facility on the west campus took place with the inauguration luncheon for 2,300 people held on the second floor of the field house.

Telecommunications

The Telecommunications Office joined a consortium of Massachusetts users intervening with the Massachusetts Department of Public Utilities (DPU) to oppose a local telephone tariff increase which would have adversely impacted MIT's communications costs by more than $500,000 annually. After hearing the consortium's and other parties' arguments, the DPU limited the increase to the extent that MIT's exposure to the tariff was reduced to about $150,000. The increased cost of communication services continues to be a problem. The recent further restructuring of long-distance tariffs will increase MIT's long-distance costs by over $350,000 a year. The Telecommunications Office is continuing its efforts to minimize the effects of these rate changes by redesigning its toll network.

Initial steps have been undertaken to evaluate possible alternative systems for the replacement of our nine-year old Centrex telephone system. Inquiries are being sent to many major communications companies including the Bell System for proposals which will be responsive to our future needs.

PAUL F. BARRETT
Planning Office

In 1981 MIT conducted its academic activities on 135 acres, 3.4 percent of Cambridge's total land area. It used 8.1 million square feet of floor area to house its academic and residential activities, employed approximately 8,000 people, and served more than 8,000 students.

The report of the Planning Office for 1981 will be principally concerned with the increased constraints on MIT's use of land for its academic purposes, the movement of large numbers of employees and students to and from the campus, the major pressures on space being generated by the academic and residential community, and the importance of preserving and enhancing our physical environment.

Campus Planning

Among the most difficult activities the Office engaged in this year were those involving major rezoning efforts on the part of the City of Cambridge -- efforts designed to control and constrain the expansion of institutional activities in various sectors of the city. While the focus of the city's efforts was principally to preserve existing low-density residential areas, the Cambridge planning and development staff and a number of public officials and citizens groups introduced an institutional zoning plan, which has as one of its principal objectives limiting institutional expansion. While not directly affected by the current proposal, MIT must take appropriate action to ensure that its ability to grow soundly and in concert with both institutional and community objectives is taken seriously, and that efforts are made immediately to preserve our remaining flexibilities. This year we have developed an accurate property inventory that will permit us to maintain on an annual basis the facts on MIT's land holdings and growth of MIT's direct contributions to the city's tax resources. We have begun work on a study which will provide dependable information on MIT's direct and indirect economic impact on Cambridge to better guide us in our development decisions in the future.

Transportation and Parking

A major revision of the Cambridge zoning ordinance's parking regulations required attention this year. Considerable time and effort were spent working with the city's community development staff and planning board to ensure that the unique parking needs of large institutions such as MIT were understood. In our opinion, the revised ordinance, while not appreciably changing parking requirements for MIT, represents an ever-increasing attitude on the part of local government to over-regulate.

At the suggestion of the Planning Office, the major employers in the Kendall Square/Technology Square/MIT area came together this year to participate in a major ridesharing campaign. Known as Kentech, the group utilized the state-operated Masspool computer-matching program to provide employees with the names of others in the Kentech area whose home location and commuting needs were similar. The success of this effort indicates that the Kentech group will continue, and matching information will be updated periodically.

Planning for Academic Departments and Schools

Planning in the School of Engineering this year focused on the proposed development of a teaching facility and lecture hall for the Electrical Engineering/Computer Sciences Department which will be known as the EG&G (Edgerton, Germeshausen & Grier) Education Center. It completes a major element of the building group originally envisaged when the Fairchild Building was constructed. In that same department, the Institute has been active this year in planning for a very large scale integrated circuit (VLSI) facility. A number of sites were explored and resources are currently being sought to install a portion of this facility in Building 39.
Major interest has been generated this year in the development of materials processing laboratories, and preliminary planning to seek ways of accommodating this important expanding activity has begun.

In the School of Science, major planning efforts have been focused on the proposed physics building. Work has also included planning studies for the Laboratory for Nuclear Sciences and the future of the Middleton facility where the linear accelerator is housed.

In the School of Architecture and Planning, planning has continued on the proposed Arts and Media facility and the consolidation of a number of architecture teaching and research functions in Building NS1.

In the School of Humanities and Social Science, the major focus for physical planning has been on the reorganization of the School's departments in Buildings 20 and 14, in an effort to rationalize organizations and communication after the program in Science, Technology, and Society moves into its new building at 70 Memorial Drive.

Planning for the brain sciences has continued this year with the development of a proposal for a new building to rehouse the Department of Psychology and bring together a number of key activities which, together with the brain sciences facility now being completed in the Whitaker Building, would concentrate the research activities in this field in one central place.

The Sloan School has been engaged in active planning for the next phase of its master plan for renovations in Building E52 and the expansion of the Senior Executive Program housing capacity at Endicott House.

Student Services and Housing

A major Housing and Transportation Survey was initiated by the Planning Office this year. Information from this survey will be used to support the efforts of a committee appointed by the president and chaired by the Dean for Student Affairs to study the Institute's housing needs. Response to the questionnaire was unusually high and the quality of information derived should be of considerable value in our efforts to determine an appropriate housing development policy for the Institute in the future.

Campus Environment and Landscape

Landscape plans were developed this year which should improve the pedestrian environment from the main campus along Amherst Street to the Sloan campus. A plan to improve Carleton Street, which leads from Amherst Street to Kendall Square and will provide major access to the Health Services facility, has required special attention. It is at the end of this street that the new subway entrance to the Kendall Square Station will be located.

On the west campus we have reviewed and updated the Amherst Alley Plan with the hope that such a plan will help generate the financial support necessary to complete this much-needed project.

Community Planning

A major effort of the Office in community planning this year has been in connection with the Cambridgeport Industrial District study. This area, lying northwest of the campus and involving many of MIT's investment properties, in particular the former Simplex Wire and Cable property, has been under intensive study involving the staff of the Cambridge Community Development Department and a number of community groups from the adjacent residential area. MIT agreed to a property acquisition moratorium during the course of this study and cooperated fully with the agencies conducting the study. A number of zoning proposals were made at the completion of this study, but because of a lack of consensus on these proposals, no final resolution by the City Council has occurred at this writing. The development of this area will have extraordinary impact on the City of Cambridge and MIT's future.
Community Service

The Planning Office participated in a number of special activities which included a national survey sponsored by the American Association of Universities on the state of academic and research facilities at a number of key research institutions in the country. This study was completed and a number of its findings have been presented to Congress. Its principal concern has been with the rapidly obsolescing state of the country's major research facilities.

Planning Research and Development of New Procedures

The Planning Office continued the development of a method for describing in statistical terms a profile of the Institute for planning purposes. This effort, begun last year, continues through this year and, when complete, will provide the Institute with a continually updated description of MIT's growth and change.

On another front, we have sought to develop, in cooperation with the Director of Finance, a capital budget planning procedure which will provide a more accurate description of the financial, programmatic, personnel, and space considerations involved in each new proposal presented for consideration. We have had excellent cooperation from a number of academic units that have participated with us, and we believe this tool will be useful in helping MIT make sound judgments about its future capital development projects.

Issues for the Future

I believe that the Institute faces difficult times with respect to meeting its goals for the development of an active academic and research program which, in turn, will require physical resources to grow and develop. Existing space is extraordinarily short; there are almost no sites for the development of new buildings convenient to the principal center of the academic campus. The pressures on the municipality for additional income will result in a wide variety of efforts to extract from employment centers such as MIT more and more revenue by one means or another. Transportation will continue to be a serious problem for the campus community and some resolution must be discovered in the near future. Housing will also be a major issue for some years to come. The limited resources available, the high cost of constructing new facilities, the limitations imposed by rent control in Cambridge, and the continuing desire of the MIT population to seek accommodations as close as possible to MIT will continue to make this a primary issue facing the Institute's planning resources and administration.

O. R. SIMHA

Purchasing and Stores

The buying staff processed and issued 60,000 purchase orders, representing a 15 percent increase over the previous year. This was accomplished without increasing the buying staff.

An automated purchase order commitment recording and reporting system, which was required to fulfill the vendor listings and reporting requirements of Public Law 95-507 and our Federal contracts, became operational on July 1. All purchase order commitments made by on-campus purchasing agencies during the year were entered into the system. By year end, more than 100,000 purchase transactions had been entered and the output of the system was being utilized as the basis for preparing reports to Federal sponsors.

The automated system also proved to be a valuable aid in accomplishing a variety of tasks unrelated to Public Law 95-507 requirements. These included:

- administration and maintenance of the Minority Business Purchasing Program,
Vice President, Operations

- establishment, administration, and maintenance of the Women-Owned Business Purchasing Program,
- providing printed records of business transacted by each purchasing agency for analysis and staffing considerations,
- providing printed records of business transacted with each vendor for negotiating discount arrangements and agreements, and
- performing initial invoice processing to streamline processing in an effort to expedite payments.

Office of Laboratory Supplies

Inventory, accounting, and billing requirements of furniture and furnishings operations were integrated into the existing automated sales reporting/billing system during the year. This substantially reduced the cost of the manual systems which had previously been used to administer and maintain these operations, and provided a greater level of support by the office staff.

Combined sales of office and laboratory items and furniture and furnishings increased 37 percent over the previous year. Sales of office and laboratory items, excluding furniture and furnishings, increased 20 percent. Sales of furniture and furnishings, excluding sales related to major renovation of existing buildings and new buildings, increased 44 percent.

Separate Purchasing Agencies

Discussions with the directors of the organizations, at which the last of the separate purchasing agencies involved in procurement under Federal contracts and grants are located, were held and will be continued during the coming year. We are attempting to streamline and strengthen purchasing operations and to be responsive to Federal audit agency recommendations that purchasing functions at MIT be centralized to the greatest extent possible and placed under the direction of the Director of Purchasing and Stores.

Minority/Women-Owned Purchasing Programs

As stated previously, the automated purchase order commitment recording and reporting system proved to be an invaluable aid in the establishment of a Women-Owned Business Purchasing Program and the administration and maintenance of both special programs.

The Institute continued to be an active member of the New England Minority Purchasing Council, a non-profit agency funded by the Federal government and its membership. Council membership consisted of 85 of the leading institutions and commercial organizations, located primarily in the Greater Boston area.

BARRY M. ROWE

Safety Office

New legislative efforts in safety have had a significant impact on departmental activities during the year. Three laws resulted in major planning and implementation efforts by members of the Safety Office -- the Occupational Safety and Health Administration's (OSHA) new Sub-part L Fire Prevention Regulations; the state building code amendment, Section 1216, dealing with automatic alarm systems in residential structures; and the Environmental Protection Agency's (EPA) Resource, Recycling, and Reclamation Act.
Laboratory Safety

Due to the requirements of EPA's Resource, Recycling, and Reclamation Act, waste chemical disposal became an even more significant activity. Volume increased 16 percent over last year although transfer of responsibility for liquid scintillation waste disposal from the Radiation Protection Office accounted for a portion of the increase. A slide presentation on waste chemical handling was developed for educational purposes. Review of large-scale technical experiments continues to be an active area for Safety Office staff.

Education and Training

Cardio-Pulmonary Resuscitation (CPR) courses and first aid training continue to be popular. The Safety Office trained approximately 500 people from 12 departments in CPR during the year. Where a continuing need exists, the Safety Office is looking into the possibility of training interested laboratory and departmental personnel as instructors for their own groups.

Laboratory safety seminars and fire extinguisher demonstrations were presented to student and employee groups throughout the Institute.

Fire Protection

Activity in fire protection can be seen on many fronts. Sprinklers have been installed in the entrance halls and various apartments of the Westgate married student complex, completing the sprinkler installation for the low-rise buildings. Currently, the sprinkler system in the Office of Laboratory Supplies storage area is being upgraded. Planning is continuing for new local fire alarm systems for the main campus.

Research Projects

The Safety Office, as a member of the National Electrical Code Ad Hoc Subcommittee on Solar Photovoltaic Systems, has been active with Lincoln Laboratory's Solar Photo Voltaic Group. The committee has been given the task of establishing an article on the subject for inclusion in the 1984 National Electrical Code. Also, the Office has been involved with the inspection of the first "lived-in" solar photovoltaic residences in Kalihi and Pear City, Oahu, and inspections are now in process on the island of Molokai, Hawaii, and at the Carlisle house (solar PV system) in Carlisle, MA.

The Safety Office conducted an Institute-wide survey of underwater diving activities. Results of this survey indicated that a diving program be established based on new OSHA standards. This program will be developed during the coming year.

Off-Campus Sites

Safety services continue to be furnished to our remote sites. Lincoln Laboratory continues to receive major attention, and significant strides have been made to upgrade their program. Some highlights were an annual spring cleanup campaign, an inventory of all hazardous chemicals, a laboratory-wide fire drill, and continued training activity in fire prevention and emergency response.

A Safety Committee has been established at the Lincoln Laboratory Flight Facility.

Haystack, Millstone, Firepond, Endicott House, and the Linear Accelerator (LINAC) also continue to receive attention.

Industrial Accidents

During the year, efforts were initiated by the Safety Office to update and reeducate departmental supervisors on the proper procedure for reporting industrial accidents, a continuing activity with changes in personnel.
Vice President, Operations

An industrial accident committee involving members of the Medical, Personnel, and Physical Plant departments periodically met to discuss industrial accident cases of employees out of work longer than three months or since terminated. Workmen's Compensation net costs for fiscal year 1980-81 resulted in an unprecedented third consecutive year of losses well below the industrial average.

JOHN M. FRESINA
Vice President, Research

The following reports were prepared by the laboratories and centers reporting to the Vice President for Research.

Francis Bitter National Magnet Laboratory

The highlight of this 21st year of the Laboratory was the completion and operational use of a hybrid superconducting and water-cooled magnet which provides a continuous magnetic field of 28.5 teslas in a three-centimeter bore. This is the highest continuous magnetic field available anywhere. A hybrid magnet built by the Laboratory for the Catholic University of Nijmegen was operated here briefly in 1977 at 30 teslas, and now provides fields up to 25 teslas in Holland. The hybrid magnet was conceived at the National Magnet Laboratory (NML) in the early 1960s, soon after the discovery of the first high field superconductors. In addition to the hybrid, the High Field Division of the Laboratory also completed a wide bore, high-homogeneity, superconducting nuclear magnetic resonance magnet producing 8.5 teslas. This magnet employs an NbTi superconductor, operating very close to the critical field.

In a continuing effort aimed at improving the accuracy, convenience, and reliability of cryogenic thermometers in high-magnetic fields, a long and complex set of measurements on carbon-glass sensors has been completed. From these, "universal" correction curves have been obtained that permit accurate temperature measurements from 1.5 to 300 K in magnetic fields up to 19 teslas.

Forbidden cyclotron resonance has been observed in light scattering from a two-dimensional electron gas in the GaAs-Al_{1-x}Ga_{x}As superlattice at high magnetic fields. In the extreme quantum limit at higher magnetic fields, the cyclotron mass increases appreciably. The observed increase in mass may be related to a possible crystallization of the electron gas.

A nondestructive and contactless optical technique of population modulation spectroscopy has been developed for a measurement of the excess carrier lifetime in semiconductors. This technique is now being applied to materials of technological importance, such as semiconducting alloys of Ag_{1-x}Cd_{x}Te.

High-intensity magnetic fields were shown to be helpful in the identification of unwanted impurities and defects in high-purity epitaxial gallium arsenide. The high fields have a very strong influence on the hydrogen-like donors in semiconductors. It was also shown that several crystalline and ceramic materials are nearly transparent to electromagnetic waves at millimeter wavelengths. Conversely, some materials commonly used at microwave frequencies have been found to have serious dielectric losses at millimeter wavelengths.

Nonlinear magneto-optical experiments were performed with a computer-controlled, tunable laser system extending through the visible to the near infrared. High-resolution two-photon absorption spectroscopy allows the observation of impurity states, free and bound excitons, and Landau levels in semiconductors under the influence of high magnetic fields. Coherent Raman spectroscopy was used to study magnetic field effects on the excitons of free and bound electrons in semiconductors.

Coefficients have been obtained for terms in a series expansion that accurately predicts the energy intervals between various low L states of ^4He for any quantum number, n. The coefficients were obtained with data from laser magnetic resonance experiments and electric field-induced anticrossings. An accurate theory for lineshape analysis of the electric field-induced anticrossings was developed.
The first calculations incorporating correlation have been made for D- ions in the high magnetic field limit; the results show much stronger binding than previously believed. Accurate calculations have been made of the electrical polarizability of the ground state of hydrogenic atoms in a magnetic field. The properties of the electronic ground state of hydrogen molecular ions in magnetic fields of arbitrary strength and direction have been studied; remarkable effects on the rotation-vibration spectrum at high magnetic fields are predicted.

Calculations, based on a recent model for liquid crystal phase transitions, indicate that high magnetic fields can alter the nature of the smectic A - nematic and smectic A - isotropic transitions. In particular, new phases can occur, as well as a crossover from first- to second-order behavior. The nematic-isotropic transition was investigated experimentally and a change in the transition temperature as a function of field was determined to be consistent with theory. Work is currently under way to determine whether a nematic-isotropic critical point is attainable with currently available fields.

Theoretical studies have been made of nonlinear interactions between electromagnetic waves and plasma waves or electrons in a magnetic field. Topics investigated include: multiply-periodic wigglers with cyclotron enhancement for free electron lasers; energy exchange between relativistic magnetized electrons and electromagnetic waves; third order nonlinear scattering of electromagnetic waves by magnetized plasmas as a probe of plasma modes.

A $^3$He - $^4$He dilution refrigerator has been operated at temperatures down to 0.04 K in a magnetic field of 11 teslas. The magneto-resistance of thin Bi and Pt films shows interesting behavior in this region, as does the dielectric constant of amorphous insulators. An improved refrigerator is now being put into operation and should reach a temperature of 0.01 K. A new, non-resonance method has been developed to measure the susceptibility of liquid $^3$He at low temperatures and high magnetic fields.

Thin, high-quality VN films have been produced with a superconducting transition temperature $T_c = 8.7$ K. Critical fields have been measured from $T_c$ to 0.09 K. These results, combined with tunneling measurements, should determine the importance of paramagnons in high-field conductivity.

Spin-polarized electron tunneling was demonstrated for the first time using vapor-deposited thin film tunnel barriers of Al$_2$O$_3$ and of amorphous Si. This development should make possible tunneling studies on many single-crystal materials.

A powder metallurgy process has been used to fabricate a multifilamentary, ultrafine fiber Nb$_3$Al high field superconductor. To date, no other method for fabricating multifilamentary Nb$_3$Al has succeeded. The critical current at high fields (and strain tolerance) of this Nb$_3$Al are comparable to that of the best Nb$_3$Sn fabricated by conventional powder metallurgy or in situ processes. Considerable improvement of the Nb$_3$Al is anticipated.

X-ray studies demonstrated that the martensitic phase transformation in Nb$_3$Sn only occurs for a narrow region of the room temperature lattice parameter. Changes of lattice parameter, by additions to Nb$_3$Sn or variation in stoichiometry, suppress this transformation with a resultant increase in upper critical field and critical current.

Magnetic moment measurements with a dc technique have confirmed earlier reports that superconductivity occurs in Eu$_{1.6}$La$_{0.3}$Mo$_5$S$_8$ at high hydrostatic pressures. Although this material is not superconducting at atmospheric pressure, a superconducting transition temperature of 11 K is observed at 7 kbar.

With support from NASA and the Department of Defense (DOD) a facility has been established at the Laboratory for investigating techniques for accelerating objects electromagnetically, and for training undergraduate and graduate students in the fundamental principles of electromagnetic energy storage, transfer, and acceleration. This technology has a number of applications to tactical and strategic weapons, to the transport of supplies to inaccessible terrain, and ultimately to the launching of space vehicles without the waste and ecological cost of chemical rockets. Other uses of electrically stored energy include plasma confinement and metal forming.

Studies of the magnetic field produced by the human heart, brain, and lungs continue. The usefulness of these non-invasive measurements for diagnosis and research, in comparison with other methods of measuring the electrical activity of these organs, is being explored. Extensive
measurements of the electric potentials and magnetic fields produced by the human brain have been made, and comparisons of these data have been performed. Several suggestions for diagnostic uses of measurements of magnetic dust in the lungs have been made.

Both North-seeking and South-seeking magnetotactic bacteria have been found in aquatic sediments from the geomagnetic equator. This finding confirms the hypothesis that the sign of the vertical component of the geomagnetic field determines the predominant cell polarity in natural environments.

Professor Alexander Rich and his co-workers in the Department of Biology have recently described a new left-handed double helical form of DNA in single crystal form. This is of considerable interest, as biological function is often closely correlated with structure at the molecular level. However, DNA and all biomolecules function in the liquid state. It is therefore of paramount importance to ascertain whether this new conformation is also present when the molecule exists in its native, liquid state. A left-handed fragment of DNA consisting of 150 base pairs was subjected to study by the new high-field 500 MHz nuclear magnetic resonance (NMR) spectrometer at the Laboratory. It was possible in this way to observe fine structural details and interactions between protons residing on the guanine base and on the ribose moiety. These experiments demonstrated conclusively that the left-handed form of DNA exists in solution. They also open the way for additional structural studies in the liquid state.

Two dimensional NMR experiments, performed on solids spinning at the magic angle, have separated the $^{13}$C chemical shift and the $^{13}$C-H dipolar interaction. This technique can be used to measure CH and NH distances in powdered solids. Aromatic ring motion was observed in solids with $^2$H NMR, showing that aromatic rings execute twofold flips in many cases. The Magnetohydrodynamic (MHD) Division of the Laboratory is under contract from the Department of Energy to develop superconducting magnet technology for their MHD energy generation program, to procure magnet systems for the national MHD program, and to transfer information to industry to assure industrial preparedness for commercial-scale systems. During the past year, two water-cooled magnets, one for the Component Development and Integration Facility (CDIF) in Butte, Montana, and the other for Avestco Everett Research Laboratory, were installed, tested, and accepted. A superconducting magnet for CDIF is under construction with most of the components completed or nearing completion. A conceptual design for a 200 MW Engineering Test Facility was developed in conjunction with NASA-Lewis Research Center. Technology Development efforts have focused on the behavior of structural materials at cryogenic temperatures, standards for structural design, overall system interface considerations, and development of improved diagnostic techniques. The component test facility, with its 6-tesla split-pair racetrack magnet system and 7-tesla split-pair solenoid magnet, is now complete and operating to provide significant-scale data on structure, superconductor, insulator, and instrumentation performance. Computational capabilities have been upgraded significantly through the acquisition of the PAFEC finite element analysis package. At year’s end, it appeared that 1982 funding for the national MHD program would be sharply reduced. The effect of this cut on the Laboratory program is now being assessed.

Research groups from throughout the world continue to use the Laboratory’s high-field magnets and high-field NMR facility. Educational activities included the completion of four Ph.D. theses, a summer session course on superconducting magnet technology, lectures during Independent Activities Period, and support of a number of undergraduate theses and Undergraduate Research Opportunities Program projects. Camilo Gomez, a student in the Department of Electrical Engineering and Computer Science, was awarded a Guillemin Prize for his senior thesis based on work done at the Laboratory. In June, colleagues and students of the director presented a one-day symposium on cyclotron resonance, magneto-optics, and related topics.

This 21st year, under the tenure of the retiring director, completes an era of the Magnet Laboratory marked by many milestones and accomplishments. The director wishes to express his gratitude to all the members of the Laboratory who have contributed to its success during these last two decades. He also extends his best wishes for continued success to Professor Peter A. Wolff who was appointed his successor effective July 1, 1981.

BENJAMIN LAX
Center for Materials Science and Engineering

The Center for Materials Science and Engineering (CMSE) funds and implements interdisciplinary research programs under the sponsorship of the Materials Research Division of the National Science Foundation (NSF). In addition, CMSE operates central facility laboratories, which are available to the MIT materials community, and offers state-of-the-art instrumentation and expertise -- to foster diverse research projects and fund opportunities in many departments. This past year has seen the installation of an ion implanter in the Microelectronics Central Facility, which has added significantly to the research capabilities previously available. In this regard, we deeply appreciate the continuing support of the MIT administration in our efforts to acquire new items of equipment, or replacement and upgrading of equipment items as user demand increases. As a parallel to our formal Area of Thrust research programs, we endeavor each year to seed-fund newly appointed faculty in the materials research program, particularly junior faculty members. The number of seed programs to be funded is limited solely by budgetary constraints, but during the past fiscal year, we were able to support four such programs on a highly competitive basis.

In addition, we continued the CMSE Colloquia Series in the fall and spring terms, covering a broad representation of subjects in the materials research field. We also continued support for the weekly series on polymer research.

Very briefly, we outline below the focus of the research programs conducted under our NSF/MRL (Materials Research Laboratory) interdisciplinary and interactive Area of Thrust (AT) programs, including the names and departmental affiliation of the individual faculty researchers.

Predicting Flow and Fracture in High Temperature Alloys

To help predict the long-time performance of high temperature superalloys, and to suggest guidelines for further alloy development, we are giving continued support to an integrated program of research on the mechanics and metallurgy of creep, crack growth, and fatigue under varying histories of stress and high temperature. Long-time extrapolation from short-time tests is always required, because superior alloys will have been developed by the time long-time (e.g., 10-year) data are available. Such extrapolation profits from a fundamental understanding of the mechanisms involved, particularly when different mechanisms dominate under long- and short-time conditions, as in transitions from transcrystalline fatigue to intercrystalline creep cracking. High-strength alloys with reasonable ductility depend upon hard second phases embedded in a ductile matrix for toughness and for creep resistance. Since the dislocation structure in the matrix is so important in controlling creep, and since interfaces play such a large role in creep cracking, those aspects of the alloy structure are the focus of our detailed studies. Some of the alloys under investigation include:

- nickel base superalloys of the γ-γ' type
- cobalt or cobalt-nickel base superalloys with carbide strengthening
- oxide dispersion strengthened (ODS) alloys

Faculty/Department: Professors Robert Balluffi, Nicholas Grant, Regis Pelloux, John Vander Sande (Materials Science and Engineering); and Frank McClintock, Robert Ritchie (Mechanical Engineering).

Deformation and Fracture in Polymer Composites

The ultimate goal of the proposed research program in this Area of Thrust is the definitive understanding of mechanical properties in a broad class of polymer composites incorporating phases of different relative compositions and shapes. These shapes range from rubbery materials to inorganic
oxides to various forms of carbon. These may be incorporated either by mechanical mixing, organized lay-ups, or by internal precipitation or phase separation. The common denominator of the research is the understanding of factors that affect the viscoelastic performance of such composites, their plastic resistance, their modes of fracture, and their toughness. These factors may have their origin in: the atomic structure and bonding of the individual phases, such as in the cavitation resistance of rubbers; in the chemistry and structure of interfaces and the state of adhesion between phases, such as in the case of coupling agents or reinforcing glass fibers, or pristine and intercalated graphite fibers; or in the size, shape, and dispersion of included rubbery phases, as in the case of toughening of block copolymers. The research is strongly interactive, and a comparatively small group brings together a broad range of complementary talents that include chemical synthesis and characterization, structure determination, electronic and lattice properties measurement, various forms of electron and light microscopy, unorthodox mechanical testing, and mechanistic modeling of mechanical phenomena.

Faculty/Department: Professors Ali Argon (Mechanical Engineering); Robert Cohen (Chemical Engineering); Mildred Dresselhaus (Electrical Engineering and Computer Science); and Donald Uhlmann (Materials Science and Engineering).

Structure and Properties of Microcrystalline and Glassy Alloys Produced by Rapid Solidification

The role and potential of rapidly solidified alloys, both microcrystalline and glassy, in terms of a developing materials science and technology, is truly outstanding. New and useful alloys in unusual compositions, which were considered to be of no practical potential just five to 10 years ago, are now being reported extensively, and our Thrust group is making an important contribution to the materials program.

The current Thrust Area research program is balanced in such a way that both scientific and engineering progress can be expected through studies directed toward gaining an insight into the nature of the electronic bonding of glassy alloys. Results are also expected to be found from studies providing a unified conceptual basis for understanding and predicting the electronic structures and glass-forming capabilities of amorphous alloys. Prototype cluster models have been constructed for Cu-Zr, Ni-Ti, and Pd-Si alloys, which exemplify two major classes of binary (A-B) glass-forming systems, namely transition metal-transition metal glasses, and metal-nonmetal glasses. Rapidly solidified alloys of interest to the Thrust group are prepared and studied for corrosion resistance, mechanical behavior, irradiation tolerance, and fine structure. A collaborative effort is in progress on the deformation and fracture studies of these rapidly solidified glasses.

For glassy alloys there is much interest in alloying to increase glass transition temperature, crystallization temperature, and strength at progressively higher temperatures. For microcrystalline alloys, there is interest in superplastic behavior, or in significantly increased hot plasticity, strength, and corrosion resistance.

Statistical measurements of the distribution of shear displacements across bands, and the rate of production of dilatation in individual bands (with increasing shear in the band), are being provided for the development of theoretical models for shear localization in hard-sphere glassy solids.

Faculty/Department: Professors Argon (Mechanical Engineering); and Keith Johnson, Roy Kaplow, Kenneth Russell, Ronald Latanision, and Professor Grant (Materials Science and Engineering).

Platinum Surfaces and Catalysts: Environmental Effects and Surface Alkyls

Platinum-based catalysts are the basis of reforming hydrocarbons in petroleum refining and are thus of enormous practical importance. A detailed understanding of these catalysts and the reactions involved in hydrogenation and reforming would contribute to the improvement of a catalyst's operation and performance. Research in this Thrust Area has concentrated on the collaborative study of two aspects of this problem:

* the effect of local surface structure and environment on reactions and catalysis, and

* the preparation, characterization, and theoretical studies of surface alkyls on platinum.
The local structure of a catalyst can affect the geometric and electronic structure of an adsorbate in ways which are just beginning to be studied and understood. The effect of morphology (i.e., steps and kinks) on simple-surface reactions and the effect of support structures (such as silica and alumina) on catalyst activity are two examples of this phenomenon. The electronic structure of coordinatively unsaturated platinum atoms and organic moieties bonded to such atoms are being studied theoretically. The effect of surface morphology on the binding and electronic structure of an adsorbate has been dramatically underscored. The angle-resolved photoemission spectrum of carbon monoxide on a stepped surface -- in this case copper (311), consisting of two rows of (111) atoms followed by a row of (100 atoms) -- showed that besides the usual molecules of CO standing perpendicular to the surface, there are CO molecules lying flat in the trough of the step, an important finding. The theoretical interpretation of these experiments is greatly facilitated by ongoing calculations on the intensities of the angle-resolved photoemission. A seed grant initiated in 1980-81 has focused on the binding of small molecules to well-characterized crystallographic ZnO surfaces using surface spectroscopic methods.

Another approach to the study of surface morphology on adsorbates has been undertaken to theoretically study the effect of steps and other surface "defects" on the adsorption energy and geometry of the adsorbate. These effects have been experimentally studied with surface spectroscopy techniques (LEED, Auger, etc.) and kinetic measurements.

Organic groups sigma-bonded to platinum atoms are important intermediates for hydrogenation and reforming reactions. A new route has been developed for generating such surface alkyls under conditions comparable to those used in catalytic reactions. This procedure provides an ideal vehicle for the study of the thermodynamics of a heterogeneous catalytic reaction. In addition, these surface alkyls have been studied by members of this research team using photoacoustic spectroscopy and electron-loss spectroscopy techniques.

Faculty/Department: Professors Robert Silbey, Read McFeely, Edward Solomon, R. Staley, George Whitesides (Chemistry); Professors Johnson (Materials Science and Engineering); and Frederick Putnam (Chemical Engineering).

Optical Materials and Devices

Research in this Thrust Area is concerned with optical insulators that have applications as sources of coherent- or narrow-band optical radiation. The materials of interest include a variety of oxides selectively doped with rare-earth and transition-metal ions that function as sensitizers and activators for the two principal processes being studied: photo- and cathodo-luminescence.

Physical measurements on these crystals have been directed toward characterizing and understanding the processes of excitation, energy transfer, and de-excitation that occur under both photon and electron beam excitation. The behavior of the transition metals Co$^{2+}$, Ni$^{2+}$, and V$^{2+}$ has been studied in a number of oxide hosts, and the role of rare-earth ions as energy transfer "bridges" between transition metal sensitizers and activators has been examined. Cathodoluminescence in oxide crystals doped with a variety of rare-earth ions (Ce, Nd, Eu, and Tm) has been under investigation with particular reference to the influence of electric fields on the intensity and dynamics of the cathodoluminescence.

Also under study by this group are the defect states of these oxide materials, with emphasis given to the manner in which the major ionic and electronic defect concentrations and states of aggregation depend upon temperature, ambient atmosphere, and dopant levels.

Faculty/Department: Professors David Epstein, Cardinal Warde, Dr. A. Linz (Electrical Engineering and Computer Science); and Harry Tuller (Materials Science and Engineering).

Amorphous Semiconductor

This sub-area is involved in the understanding of the electronic structure of amorphous semiconductors and the differentiation between the contributions of short-range and long-range order to the physical properties of crystalline and amorphous semiconductors.

The divalent nature of chalcogen atoms introduces a flexibility into the structure of halide glasses that does not occur in tetrahedrally bonded materials. This flexibility has proved very useful, as is evident from the fact that chalcogenide glasses are widely used as the active material
in xerographic copying, vidicon tubes, and electronically alterable memories. This Thrust group has shown that the unusual behavior of these materials can be explained by the existence of a particularly low energy defect, called a valence-alternation pair (VAP). Both experimental and theoretical efforts are currently being made to analyze the possible defects in amorphous semiconductors and to determine both their nature and their energy levels. Time-resolved photoluminescence with polarized-light excitation has provided a powerful tool for study of these defect states. Both reactive sputtering of chalcogenide glasses in hydrogen/argon mixtures and co-sputtering with alkali atoms have been found to increase the density of states in the gap. Other techniques such as drift, diffusion, and ion implantation are being used to incorporate the alkali modifiers, as well as Group III modifiers (such as Al and In) suggested by theoretical work being done by this Thrust Area. Detailed calculations have been carried out on the defect levels in amorphous As and amorphous chalcogenides such as As₂Se₃.

Faculty/Department: Professors David Adler (Electrical Engineering and Computer Science); and Marc Kastner, John Joannopoulos (Physics).

Microelectronics Materials and Devices

The research thrust on microelectronic materials and devices within the NSF/MRL program focuses on the problems and issues encountered in density and performance requirements of state-of-the-art integrated systems (VLSI). These systems force device dimensions to submicron levels and device speeds to picosecond levels, and increasingly reduce defect tolerance levels. It is believed that the development of new generations of ultra-small, ultra-fast devices and VLSI circuits depends primarily upon developing new materials systems for use in active electronic circuits. Members of this Thrust group also believe that increasing the understanding of defects induced in materials (particularly silicon), by present processing techniques, and increasing the understanding of the energy levels and defects introduced by, and associated with, interfaces between materials, will help the development of these circuits.

The materials systems being studied are heteroepitaxial III-V quaternary layers and plasma-deposited silicon films and epitaxial layers. The process-induced defects that are being studied are those induced by ion implantation and thermal oxidation of silicon, and the interfaces of interest include insulator-semiconductor interfaces, and semiconductor-semiconductor heterojunctions.

Central facilities at CMSE play an important role in the program of this Thrust group, and much of the work requires extensive use of the Microelectronics Laboratory and Ion Implantation Facility. Extensive use is also made of the Scanning Electron Microscope and Surface Analytical Facilities of CMSE.

Faculty/Department: Professors Clifton Fonstad, Dimitri Antoniadis, Stephen Senturia, and Rafael Reif (Electrical Engineering and Computer Science).

Phase Transitions

The basic research programs in this Thrust area concern the structure, static thermodynamic properties, and dynamic behavior of materials undergoing order–disorder phase transitions. Insights gained from previous work on simple critical phenomena have been extended to the phase transitions that occur in more complex materials. Considerable progress has been made on multicritical and percolation transitions in ionic crystals, the growth of micelles, the initial formation and critical collapse of gel phases, and a variety of new critical phenomena in liquid crystals. Work has continued in these areas during the past year as have research projects designed to extend and clarify our understanding of critical phenomena and discover the basic mechanisms that underlie phase transitions in complex systems.

The group is particularly strong in terms of experimental skills; and a wide variety of sophisticated and often unique experimental capabilities are available. The combined experimental efforts of this group provide significant tests of current theories and also provide the physical insights necessary to point out the direction for new theoretical models. Closely coupled theoretical efforts define the types of global phase diagrams that arise from complex microscopic models and identify the character of various multicritical singularities. The conjunction of experiment and theory provides a fundamental approach to the investigation of materials properties near phase transitions and the factors that determine the stability of various phases.
The themes of this Thrust Area also focus on multicritical points in solids, liquids, and liquid crystals. Multicritical points are of special significance, since they represent changes from a continuous cooperative effect to a discontinuous first-order transition in situations where there are two or more competing interactions. There are physical systems where a multicritical point can be realized by the application of hydrostatic pressure, by the application of an external field, or by a variation in composition, and all of these approaches are under investigation.

Faculty/Department: Professors Carl Garland (Chemistry); and Robert Birgeneau, James Litster, Thomas Greytak, George Benedek, Ahmet Berker, and Toyoichi Tanaka (Physics).

Research Using Synchrotron Radiation

When the decision was made to build a National Synchrotron Light Source at the Brookhaven National Laboratory, we saw this as an opportunity to enter new research areas previously inaccessible for lack of sufficient photon intensity in the appropriate photon energy ranges. We therefore seeded a new initiative in our NSF/MRL program on Research using Synchrotron Radiation, taking advantage of the outstanding talent at MIT in scattering spectroscopy. To instrument a synchrotron port at Brookhaven, Professors Birgeneau, Litster (Physics), and Bernhardt Wuensch (Materials Science and Engineering) have joined forces with Drs. Paul Horn and Slade Cargill of IBM to form a joint participation research team. This team has already received first-round approval from Brookhaven for the installation of such a port. Some of the research opportunities that will be exploited at the new synchrotron port include high-resolution studies of freely suspended smectic liquid crystal films to yield detailed information on the characteristics of the rich variety of phase transitions occurring in these systems. Other areas of research opportunities to be vigorously pursued include very high resolution studies of the magnetic field dependence of structural/magnetic phase transitions in systems with strong magneto-elastic coupling, and high-resolution scattering experiments at very high pressures. Our present efforts have been directed toward instrumenting the synchrotron port, and it is hoped that the port will be ready for operation in the fall of 1981 when the synchrotron light source is turned on.

MILDRED S. DRESSELHAUS

Center for Space Research

During the past year the MIT Center for Space Research (CSR) has continued an active program of research in space science and technology. Major programs include X-ray astronomy, interplanetary and magnetospheric plasma physics, the life sciences, properties of planetary surfaces and atmospheres, and radio astronomy. Although the Center is engaged in several long-range flight programs sponsored by NASA, actual flight dates for almost all of these experiments are extremely uncertain because of corresponding uncertainties in development of the Space Transportation System (the Space Shuttle). For this reason there has been little construction of actual flight hardware, and our major activities have centered on data analysis and the development of techniques and instruments which will be needed for future missions. In addition, the Center has played an increasing role in the development of modern instruments suited for use at ground-based optical telescopes.

Although the short-term prospects for new missions and new flight opportunities are very poor, the long-range NASA plans include several missions which will almost certainly be flown at some future date. These include a sophisticated X-ray observatory, the Advanced X-ray Astronomical Facility (AXAF) which will contain a large X-ray telescope and a number of instruments which can be placed in the focal plane of the telescope. This facility will be similar in purpose to the Large Space Telescope now under construction and will serve a large community of observers. Several members of the CSR staff are actively engaged in developing instruments and detectors which will be suitable for this mission. Other instruments or concepts of instruments which might be flown on various future missions are also under study and development. The following is an overview of the programs conducted within CSR during the past year.
X-RAY ASTRONOMY

Satellite-Borne Experiments for X-ray Astronomy

A major program of data analysis continues to yield many new results in the field of X-ray astronomy. The data base includes results from four MIT experiments flown on the SAS-3 satellite under the direction of Professor George W. Clark, two experiments on the HEAO-1 satellite directed respectively by Professor Hale V. Bradt and Professor Walter H.G. Lewin and one experiment on the Einstein Observatory (HEAO-2) under the direction of Professors Clark and Claude R. Canizares. The work includes studies of X-ray pulsars and bursters to determine the physical structure of these objects and the mechanism responsible for emission of the X-ray bursts. A second area of major interest is a systematic study of optical counterparts of these faint X-ray sources. A third area of interest is the long-term variability of bright X-ray sources, including studies of X-ray pulsars and transient sources. Finally, the MIT focal plane spectrometer on the Einstein Observatory continued to operate well until the HEAO-2 spacecraft ceased operation in April 1981. This instrument has provided the first measurements of X-ray emission lines from the hot gas which surrounds supernova remnants, giant galaxies, and other astrophysical objects. Observations of these lines yield new astrophysical data unobtainable in any other way. As examples, the presence of various elements and their relative abundances have been established in some supernova remnants; the Doppler shifts of the X-ray emission lines have been used to establish the velocity fields of the gas clouds in supernova remnants; and the temperature profiles have revealed the accretion rate of gas around active galaxies.

Balloon and Rocket-Borne X-ray Experiments

Observations of celestial X-ray sources have been carried out by the Center since the late 1960s by means of balloon-borne and rocket-borne instruments. In fall 1980, a test balloon flight was conducted which used a small array (approximately 8 cm²) of mercuric iodide solid-state X-ray detectors. The primary purpose of this test flight was to begin the process of "space qualification" of these new detectors. In particular, the objectives were to establish the background levels and possible activation effects of the charged particle environment in this new material. The ultimate objective is the use of these detectors in various experiments to be carried on future space missions. This test flight achieved its objectives, and a larger balloon-borne experiment is in preparation. The experiment was carried out by John Vallerga under the supervision of Dr. George R. Ricker. The development of these mercuric iodide detectors is an ongoing activity in the area of detector technology and is described in a later section of this report.

During the past several years, the MIT X-ray Astronomy Sounding Rocket Group, under the direction of Professor Saul A. Rappaport, has designed, constructed, and flown an imaging X-ray experiment which has a wide field view (8°) and is sensitive to soft X-rays in the region 50-250A. This payload was first flown successfully in July 1977. It has been continuously improved since that date and was reflown in March 1978. During the past year, the telescope mirror system has been improved, and an imaging detector which consists of a 50mm diameter microchannel plate has been provided by our collaborators at the University of Leicester. This instrument is expected to yield important new astrophysical results in the soft X-ray region. It is scheduled for flight in the fall of 1981. R. Petre and Edward Boughan are responsible for this flight.

Optical Studies of X-ray Sources

This program being carried on by Drs. Jeffrey McClintock and Larry Petro is designed to study the optical properties of X-ray sources. The observations have been made principally with telescopes at the Cerro Tololo Interamerican Observatory in Chile and the McGraw-Hill Observatory on Kitt Peak. In previous years, the main thrust of the program has been to determine the nature of low-mass X-ray binaries and has involved simultaneous observations of X-ray and optical emissions from known X-ray burst sources. During the past year, a new line of investigation was initiated -- one which involves a photometric search for orbital periodicities in these systems. This program uses a new scanning slit photometer constructed especially for this program. It is capable of precise measurements in star fields in which the stellar separation is as small as the seeing disk (about 2°). This instrument has been used to observe about seven X-ray binaries, and is providing detailed information on the nature of the optical members of these systems.
Another optical program involves the identification and study of quasars and active galaxy nuclei initially located through X-ray observations. A new sample of 26 such objects was found by Gerard Kriss and Professor Canizares.

Observations of Interplanetary and Magnetospheric Plasmas

The IMP-8 spacecraft was launched in 1973. It is in an eccentric earth-orbit and has provided a continuous data base of solar wind plasma conditions at 1 Astronomical Unit (AU) for the past eight years. These data are used to study the interaction of solar wind streams by comparing structures at 1 AU with those observed from Voyager 1 and 2. Data from these latter spacecraft have been obtained to distances beyond 10 astronomical units and the evolution of the stream structure over such great distances is dramatic. At 1 AU, the fluid parameters which characterize the solar plasma change markedly during one solar rotation and there are also large variations in the stream structure. In contrast, at 10 AU (roughly the distance to Saturn) the structures in the velocity profile are much less pronounced, although variations in density and temperature are still pronounced.

The Voyager 1 and 2 spacecraft were launched in fall 1977. Each spacecraft carries a plasma investigation which is under the direction of Professor Herbert S. Bridge and is designed to investigate properties of the distant solar wind and to study the magnetospheres of the outer planets. The flybys of Jupiter in March and July of 1979 were extremely successful and a great deal of analysis and interpretation of data obtained in those encounters has been accomplished in the past year. One of the most exciting recent results of the plasma measurements at Jupiter comes from a detailed interpretation of data obtained as the spacecraft passed near the Io flux tube. The increase of plasma flux observed during this time results from the presence of an Alfvén wave which carries a current between Io and the Jovian ionosphere. At the time Voyager 1 passed near the Io flux tube, the corotating plasma entered the detectors at a large angle, and the perturbation of plasma flow velocity associated with the presence of the Alfvén wave caused the plasma to flow more directly into the sensor, and thus increased the observed flux. A detailed consideration of the magnetic field data confirms the presence of the Alfvén wave and has led to a fundamental revision of our ideas about the interaction of Io and the magnetospheric plasma. This result also provides a basis for understanding the correlation of decametric radio emissions from Jupiter, with the position of Io in the magnetic field of Jupiter.

The Voyager 1 spacecraft passed through the Saturnian system in November of 1980. The spacecraft made a very close approach to the large satellite Titan and approached the planet itself to within 3.07 Saturnian radii. The plasma experiment was extremely successful, and major information was obtained concerning the Saturnian magnetosphere and the interaction of the magnetospheric plasma with the satellite Titan. The general morphology of Saturn's magnetosphere is well represented by a plasma sheet which extends from at least 5 to 17 Rs and is symmetric with respect to Saturn's equatorial plane and rotation axis. The magnetospheric plasma contains both light and heavy ions, probably hydrogen and nitrogen or oxygen. Most of the magnetosphere appears to corotate with a velocity within 20 percent of that expected for rigid corotation. The spacecraft's encounter with Titan took place inside the magnetosphere, and the data show a clear signature characteristic of the interaction between subsonic corotating magnetospheric plasma and the atmospheric or ionospheric exosphere of Titan. The atmosphere of Titan appears to be a significant source of ions for the outer magnetosphere of Saturn.

The plasma experiment on Voyager 1 suffered a partial failure shortly after the spacecraft passed Saturn. So far it has been impossible to restore the experiment to proper operation. The experiment on Voyager 2 continues to operate normally and the spacecraft will pass through the Saturn system in August 1981. Present plans are to continue the mission through the Voyager 2 encounters with the planet Uranus in 1986 and Neptune in 1990.

Physics of Space Plasmas in the Earth's Magnetosphere and Ionosphere

In August 1979, a program of theoretical research on physics of the terrestrial magnetosphere and ionosphere was initiated under sponsorship of the United States Air Force. These studies apply the basic kinetic theory of charged particles moving in a magnetized environment to problems in weak and strong plasma turbulence, plasma instabilities, and collective effects on wave-particle interactions. The specific phenomena considered in this research program include:
Center for Space Research

diffuse and discrete aurora; magnetic merging and reconnection in the magnetotail, and in particular the relationship of these phenomena to the onset of magnetic substorms; the origin of the auroral kilometric radiation; the formation of non-Maxwellian ion and electron distributions; excitation of electrostatic ion and electron cyclotron waves; VLF whistler modes; lower and upper hybrid instabilities; the trapping and precipitation of energetic charged particles; the effects of photoionization; and beam plasma interactions. Special attention has been paid to relativistic effects in the application of the theory to some of these problems. Dr. Tom S. Chang, and Professors Bruno Coppi, and Stanislaw Olbert are involved in this program.

Spacelab 1 (Vestibular Experiments)
The program being carried out under the direction of Professor Laurence R. Young, Department of Aeronautics and Astronautics, will provide a series of vestibular experiments on Spacelab 1 to test theories of human reaction in the gravity-free environment of space. The Center furnishes management and engineering support for the program. Two sets of flight experiments have been delivered to NASA, and astronaut training is proceeding toward a flight in mid-1983. Seven separate experiments are planned, some in collaboration with Canadian and European space agency investigators. The experiments range from the measurement of various responses to head motions, to hopping experiments which will test otolith changes during weightlessness. Memory/disorientation experiments focusing on previous problems experienced by astronauts in the Skylab mission will also be conducted. Professor Young is assisted in the Spacelab experiments by Dr. Charles M. Oman of the Department of Aeronautics and Astronautics.

Reflectance Spectrometer Research for Possible Mars Orbiter and Comet Missions
The Center is conducting preliminary design and breadboard development of a reflectance spectrometer instrument (RSI) to demonstrate the capability of an optical/IR spectrometer of moderate resolution in order to determine the composition of material of inner solar system bodies by studying their reflectance spectra. In addition, by incorporating detectors in the direction perpendicular to the spectral dimension at the focal plane, spatial information is simultaneously obtained for several selected wavelengths. Detector evaluation is continuing, as well as optical and electronic design, so that a specific instrument can be designed readily for a potential comet or asteroid mission. A ground-based version of this instrument concept is currently being designed and fabricated.

The research program is under the scientific direction of Dr. Thomas B. McCord of the University of Hawaii. Local supervision of the technical aspects is provided by Dr. Joseph H. Binsack of CSR.

Mission Definition Study of a VLBI Network Utilizing the Space Shuttle
This research program, under the direction of Professor Bernard F. Burke of the Department of Physics, is to investigate the concepts and methods of implementation of an orbiting Very Long Baseline Interferometer (VLBI) terminal in space. Earlier investigations concentrated on small antennas fixed-mounted inside the Shuttle. Current concepts will draw on other NASA studies of large deployable antennas of 50-100 meter diameter. Antenna-pointing accuracies, stability and dynamics, RF feed configurations, and data-handling techniques are being investigated by MIT in conjunction with the Marshall Space Flight Center's deployable antenna program. Professor Burke is assisted by Professor David Roberts of Brandeis University and Dr. Rodger Doxsey of CSR.

Venus Orbiting Imaging Radar
The main purpose of this new NASA mission to Venus is to map the surface of this cloud-shrouded planet using a Synthetic Aperture Radar (SAR). The data from the radar will be processed into mosaics to yield a global map of the planet at 300-meter resolution. This map will be used to describe and locate the major geological regions in an attempt to understand the processes that have shaped the surface of Venus and led to the evolution of its distinctive atmosphere.
Dr. Gordon H. Pettengill of the Department of Earth and Planetary Sciences is the principal investigator of the SAR. He leads a large team of scientists from around the world who are working with NASA to design and develop the SAR and VOIR programs, and who are preparing to process and interpret the very high rate data received. Members of the team at MIT include Professor Sean Solomon and Drs. Binsack, William F. Mayer, and Barry Parsons. The VOIR is currently scheduled for launch in 1988.

OTHER DETECTOR AND INSTRUMENT DEVELOPMENTS

Mercuric Iodide Detector Development

Two years ago, Dr. Ricker initiated investigation and development of a new type of solid-state detector made from mercuric iodide. The material appears to be extremely promising as an X-ray detector, and it forms the basis for the development of detectors for the HgI₂ X-ray spectrometer under development for AXAF and other missions, and for the balloon-borne HgI₂ experiment described in a previous section. The outstanding advantage of this detector is its ability to operate satisfactorily near room temperature as a nondispersive spectrometer. All semiconductor X-ray detectors previously used in X-ray astronomy have required cryogenic cooling, which is a major disadvantage for satellite or balloon-borne experiments. Two configurations for instruments based on this detector are currently under study. The first will be optimized for the energy range where reflecting X-ray optics are effective (about 0.5 to 5 keV); it should be almost ideally suited for use as a focal plane instrument on the AXAF. We hope that this detector will operate five to 10 years without degradation or need for refurbishment. The second instrument configuration under study is optimized for high energies (greater than 20 keV); it should be especially suited for detecting cyclotron and nuclear lines in cosmic X-ray sources, and should have greatly increased sensitivity in comparison with instruments currently available. In parallel with the program of instrument development, we are exploring the crystal-growing techniques in an effort to improve the inherent resolution of the detector and to provide a reliable source of detector-grade crystals.

Bragg Reflection X-ray Spectrometry

The development program for Bragg reflection X-ray spectrometers continues. This work was originally initiated by Professor Clark and led to the highly successful Bragg crystal spectrometer on HEAO-2. It is currently being carried on by Professor Canizares, Dr. Thomas Markert, and Frederic Marshall. During the past year, major improvements have been made in the test spectrometer and the X-ray source. Several new crystal materials have been investigated and additional work has been done in developing techniques of cleaving these crystals and bending them into the required shapes.

Hard X-ray Concentrators

In the low-energy region of the X-ray spectrum, say up to about 2 keV, imaging and non-imaging mirror systems have been developed to a high degree of sophistication. These devices have been an essential element in many experiments which have been responsible for the spectacular progress in the field of X-ray astronomy in the past five years. At higher energies, grazing incidence optics constructed of conventional materials can no longer be used, and some time ago Dr. Ricker and his colleagues realized that one could use Bragg reflection from highly oriented pyrolytic graphite or from lithium fluoride. This work shows great promise for the X-ray region up to 40 keV and perhaps beyond. We are constructing several prototype concentrators to more fully explore the techniques of construction and to characterize the optics of these devices.

Application of Charge-Coupled Devices

In addition to the development of mercuric iodide detectors, Dr. Ricker has been conducting a program of research directed toward the development of X-ray and optical cameras based on the use of charged-coupled devices (CCDs). The research group involved in this project includes
Dr. S.S. Meyer and D. Dewey. The use of CCD sensors has developed very rapidly in the recent past and they show great promise for future optical, infrared, and X-ray imaging applications. They combine high-quantum efficiency, wide dynamic and spectral ranges, and unusual geometric and photometric stability. In the past year, we procured several of these devices from Texas Instruments Corporation (TI) as a special purchase arranged in cooperation with the Charles Stark Draper Laboratory. All of these devices contain 490 x 328 pixels on a chip roughly 12 x 8mm. Some were procured in the configuration suitable for the detection of X-rays and some in a configuration suitable for optical work. A detailed characterization of the devices both in optical light and in X-rays is in progress.

Two of these TI devices have been used to construct a faint object spectrometer/imager which we call MASCOT (MIT Astronomical Spectrometer Camera for Optical Telescopes). This CCD camera was initially tested at the MIT Wallace Observatory on the 24" telescope. After the initial test runs at Wallace, extensive testing was carried out at the 52" telescope of the McGraw-Hill Observatory on Kitt Peak. In the photometer mode, MASCOT appears to be superior to the best instrumentation currently available and used routinely on the 200" telescope at Palomar. In the spectrometer mode, MASCOT is not yet as sensitive as the best instrument available, but future improvements in the readout noise of our CCDs are expected to provide superior performance in this area. While presently using the McGraw-Hill 52" telescope, spectral measurements can be made on objects as faint as m-21 and photometric measurements can be made on objects as faint as m-24. These values are for a one-hour integration time. The development of MASCOT constitutes a real advance in modern high efficiency photon counting instrumentation for ground-based astronomy, and has obvious applications for balloon- and satellite-borne telescopes.

Development of an X-ray Objective Grating Spectrometer

A new activity undertaken during the past year by Professor Canizares is the development and evaluation of X-ray transmission gratings, fabricated by a group at MIT. A high-quality objective grating spectrometer on AXAF would be a major research tool for the study of both galactic and extragalactic X-ray sources. With its potential of high spectral resolution, high throughput, and ability to access the entire spectrum in a single measurement, an improved objective grating spectrometer would outperform both nondispersive detectors (such as the mercuric iodide solid state detector discussed above) and bent crystal spectrometers (such as those used by the MIT group on HEAO-2) for almost all important astrophysical studies. Instruments of this type have been developed by several other groups but their present construction techniques have certain fundamental limitations which will prevent them from achieving a performance which is competitive with that of an instrument based on MIT gratings. These improved gratings are made possible by the work of an MIT/Lincoln Laboratory group under Professor Henry Smith. The grating fabrication is an outgrowth of a larger program of research on the technology and applications of submicron structures which involves many techniques and has been used to produce a variety of structures.

FUTURE MISSIONS

In the 1979-80 Report of the President and the Chancellor, we reported on several proposals for flight experiments which were in preparation or had been submitted to NASA. Of these, one has been accepted, although not in its original form, and two are still under serious consideration by the Agency.

An Ion Mass/Velocity Spectrometer for the Mission to Halley's Comet

The objectives of this investigation are to study the physical and chemical processes occurring in the ionospheres of comets and to understand the interaction of comets with the solar wind. As members of a group led by Dr. Marcia Neugebauer of the Jet Propulsion Laboratory. Dr. Alan Lazarus and Professor Bridge proposed a plasma experiment for this mission. Although the experiment was accepted by NASA, the program was subsequently cancelled. The proposal was resubmitted to the European Space Agency (ESA) for inclusion on the ESA mission to Halley known as the Giotto Mission. This proposal was accepted by ESA, and a limited amount of funding has been made available by NASA for participation of the US investigators. The investigation is now under the leadership of Professor Johannes Geiss of the University of Bern.
Origin of Plasmas in the Earth's Neighborhood (OPEN)

The OPEN program consists of a series of four satellites at various positions in the earth's magnetosphere which monitor its response to changing conditions in the solar wind. These solar wind conditions are recorded by another satellite at the libration point upstream of the magnetosphere. Several members of the CSR are members of groups which submitted proposals for this mission during the past year. The evaluation of these proposals has been completed but no final decisions have been announced by NASA.

X-ray Timing Explorer

The Center has continued to pursue concepts for high time resolution X-ray measurements of celestial objects. There is intense interest in the community of X-ray astronomers in this mission and an Announcement of Opportunity to propose experiments for this mission was issued by NASA during the past year. A group under Professor Bradt submitted a detailed proposal for the mission. This proposal represents a major scientific and engineering effort by CSR. Similar proposals were submitted by several competing groups and the evaluation is in progress.

THEORETICAL ASTROPHYSICS

The past year has seen the successful culmination of our efforts to achieve a major expansion of the theoretical astrophysics group at MIT. Professors Paul C. Joss, Lenox Cowrie, and Scott Tremaine are presently in residence at MIT. This fall Professor Charles Alcock will join the group and Dr. Anna Zytkow will join the CSR staff as a principal research scientist. Research activities of this group are described elsewhere. They receive strong support from the Center, and we anticipate a strong and fruitful interaction with them and the members of the experimental groups.

HERBERT S. BRIDGE

Energy Laboratory

The main role of the Energy Laboratory is to encourage mission-oriented research on a broad range of energy problems through the interactive participation of people drawn from most of MIT's academic departments. The greatest single research emphasis is the efficient, economic, and socially responsible use of the increasingly "dirty" fuels of the future such as coal, tars, heavy crudes, and shale. Specific projects focus on combustion in furnaces and engines, health effects of emissions, supply and demand studies, and conversion to clean fuels. In addition to that work, Laboratory programs include research on conservation, renewable energy sources, nuclear energy, and conventional oil and gas in both technological and economic/policy projects.

Operating expenses of the Energy Laboratory during fiscal year 1981 were about $12.7 million -- an increase of about 0.9 percent above last year. Funds to meet those expenses were provided by sponsors of research projects (55 percent by the Federal government) and by industry and foundations in grants and gifts. The number of faculty associated with the Laboratory during the year totaled 53, the Laboratory professional research staff 104, and participating students 280 (190 graduate and 90 undergraduate students). In addition, about 39 professional research staff from other MIT departments, laboratories, and centers participated in Laboratory activities.

With an eye toward improving overall planning and operating effectiveness while maintaining the independence of individual program areas, the Energy Laboratory made a number of changes in its organizational structure since June 1980. Three associate directors were appointed with cognizance for broad areas of Laboratory research: Professor Henry D. Jacoby of the Sloan School of Management (energy management and economics); Professor Thomas H. Lee of the Department of Electrical Engineering and Computer Science (energy systems); and Professor John P. Longwell of the Department of Chemical Engineering (fossil fuels technology). The new
Planning Committee, chaired by Laboratory Director Professor David C. White and composed of the Laboratory's program directors and managers, has assumed responsibility for identifying long-range objectives for the Laboratory, with emphasis on research directions deserving priority allocation of resources. Also established within this period was a Management Committee, which has overview responsibility for implementing broad Laboratory policies. Deputy Director Dr. Malcolm A. Weiss is chairman of this committee; other members are Professor White and the Laboratory's three associate directors. Some changes in membership of the Energy Laboratory Advisory Board were also made to broaden representation from the energy-using and energy-producing business communities. At its annual meeting in March, the Advisory Board discussed energy research and education at MIT, future directions for the Laboratory, and what broad topics deserve emphasis and priority allocation of MIT's resources.

Another change in the Laboratory's structure during the year was the establishment of a Synthetic Fuels Center (SFC). Research on both technology and policy programs involving synthetic fuels has been under way at MIT for many years, both inside and outside the Laboratory. Creation of the SFC is intended to provide a focus for existing research and to encourage and coordinate a broader synthetic fuels program at MIT. For those members of the MIT community who choose to associate their work with the SFC, it will attempt to identify promising new research opportunities; provide help with know-how or funding, or both, for new projects; assist in project execution and reporting; establish strong links with private and government groups in synthetic fuels; encourage interdisciplinary projects; and function as a focus at MIT for information and inquiries. Dr. Weiss has been appointed the first director of the SFC.

In addition to participating in MIT academic activities, Energy Laboratory researchers continue to interact closely with people and organizations outside MIT. The Energy Laboratory's three formal vehicles for such interaction -- the Center for Energy Policy Research (CEPR), the Electric Utility Program, and the Advanced System for Process Engineering (ASPEN) -- have continued their activities.

The CEPR has expanded to 37 the number of associates that support and contribute to its work on the research and analysis of energy policy. This number includes the six organizations that signed initial three-year participatory agreements when the CEPR was being formed and that have now renewed their affiliations. Loren C. Cox of the Energy Laboratory succeeded Professor Jacoby as director of the CEPR. Professor Jacoby will now chair the Center's Operating Committee, which helps guide the research of the CEPR. Two major meetings were held during the year. In November, the Center organized a wide-ranging workshop on research and policy issues in the context of developments within the world oil market. The second meeting was held in May and focused on current future activities of the Center itself. The results of a CEPR research project, on the resolution of conflicts involved in siting energy facilities, were published in the form of a handbook for use by the affected communities and developers; many of the recommendations contained in the handbook have now been incorporated into Massachusetts state law.

Eight utilities participated in the 1981 Electric Utility Research Seminar and Workshop Program. Workshops in the past year have considered utility strategic planning, load management and conservation, electric systems and equipment, nuclear engineering, fossil fuel utilization, and environmental management. Four new contracts resulted from the workshops this year, and funding was renewed for a fifth, ongoing contract.

Tests of ASPEN being conducted by over 50 major companies have continued throughout the year and are scheduled for completion this fall. A symposium was held this spring to discuss the project's work on computer-aided process design. The project has recently been expanded to handle nuclear facilities; a workshop was conducted on this newer aspect of the project in June.

This year saw the initiation of a three-year study concerning the fundamental causes of and potential solutions to the nation's long-term energy problems. The three major areas of study are: energy prices, availability, and macroeconomic policy; distributional issues of energy and environmental policy; and microeconomic, institutional, and regulatory dimensions of energy and environmental policy.

Recent government cutbacks are anticipated to cause many changes in Laboratory research. The coming fiscal year will show us the scope of these changes and the directions our attention must take to remain a vital part of both the MIT and the energy research communities.
Vice President, Research

The following material describes the major thrust of the Energy Laboratory's principal research areas. More information on the specific projects being performed within the Laboratory may be obtained from the Summary of Energy Laboratory Activities for the Fiscal Year 1981 and Project Summaries, July 1, 1980 – June 30, 1981, both of which describe all Energy Laboratory projects. The Laboratory's quarterly newsletter, e-lab reports on current research results of particular general interest.

RESEARCH

The Energy Laboratory's International Energy Studies Program focuses on economic, political, and strategic aspects of the international energy trade. Research is conducted on international markets in oil, nuclear fuels, and other energy commodities, and analysis of conditions in supplier and consumer nations. New directions for research include relationships between US energy security and international systems and policies, financial aspects of wealth transfers resulting from energy trade, and the energy problems of the developing world.

The focus on the Utility Systems Program lies in three major areas: 1) electric utility operations and control; 2) economics and policy decisions associated with adoption of new, generally utility-interfaced energy technologies; and 3) development of modeling tools for both utility operation and utility capacity expansion analysis. This program draws on the abilities of MIT's engineering and policy science departments to analyze short- and long-run utility operations and growth.

The Energy Markets, Pricing, and Regulation Program examines the structure and performance of the domestic system for the supply, conversion, and use of energy, and the interactions between that system and the domestic and international macroeconomy. Continuing research on determinants of primary energy supply focuses on oil, gas, and coal, with current emphasis on the interaction between environmental and coal development policies. Research on energy demand focuses on the determinants of factor use and productivity in manufacturing activities. Closely related to this program is a continuing series of evaluative studies of major energy, economic, and air quality models and policy studies.

The Center for Energy Policy Research (CEPR) performs research and analysis on energy policy and makes its results available and useful to policy makers. With support from a wide range of corporate and noncorporate interest groups (called associates), the Center holds conferences and seminars to bring together key government and private organizations to work on energy policy issues. The work of the Center is carried out by Energy Laboratory personnel, people from several MIT departments, and specialists from the CEPR's associates.

In the Energy Systems Program, future energy systems options are studied by considering a combination of the most promising technologies that may have a significant impact on national and global energy problems. This program has two important tasks: 1) to construct and evaluate the impact of energy system options for different societies both in the near term and the long term; and 2) to identify research and development needs and to initiate projects to solve the identified problems.

The emphasis of the work of the Energy Conversion Program is on high temperature gas turbines with related hot gas cleanup and cooling, fluidized and electrofluidized beds, environmental assessments of advanced energy conversion systems, and magnetohydrodynamic (MHD) power generation. The fluidized bed program is concerned with mathematically modeling fluidized bed combustion and establishing a data base management system for the technology. The MHD program has been considering a wide range of MHD-related topics.

The modeling and investigation of combustion processes of many fuels in steady and unsteady operation are emphasized in the Laboratory's Stationary Combustion Program. Specific projects include: turbulent combustion in furnaces and combustors; reduction of pollutant emissions from liquid fuel spray flames; radiative heat transfer from flames in furnaces; soot formation; combustion characteristics of coal/oil mixtures and coal/water slurries; behavior of nitrogen in coal; fluidized combustion; NOx emission from shale- and petroleum-derived liquids; and spray combustion.
The attention of the Health Effects Program is concentrated on determining the mutagenic, carcinogenic, and respiratory toxicity of combustion-generated particulates and polycyclic compounds. A unique feature of this program is a direct coupling of research teams in engineering, analytical chemistry, and the biological sciences.

The new Synthetic Fuels Center provides a focus for research on conversion of coal, oil shale, and other energy resources to liquid and gaseous fuels. All aspects of synthetic fuel production and use are of potential interest; some current Laboratory research projects include pyrolysis and/or hydropyrolysis of coal and biomass, catalytic hydrogenation reactions, and shale oil recovery systems.

The Process Modeling Program focuses on computer simulation of industrial processes. The ASPEN project is developing a next-generation process simulator to perform steady-state heat and material balances, equipment sizing, and cost estimation and economic evaluation.

Work performed under the Transportation Propulsion Program is based on the activities of the Sloan Automotive Laboratory. Research programs include: fundamental combustion studies; research on internal combustion engines and gas turbines; lubrication studies; work on automotive systems and control; and policy and technology studies.

The Energy Laboratory's Advanced Technology Program examines new and emerging technologies. Topics of interest include: electrodes and electrolytes for high energy density batteries and fuel cells; electrochemical processing; synthesis and modification of ceramic powders using laser heat sources; microstructural control in materials for ceramic processing, solar heating/cooling; amorphous photovoltaics; and broad band antireflective coatings.

The Environmental Management Program seeks to identify and reduce the environmental impacts of energy-related facilities. Current efforts include the design of open- and closed-cycle cooling systems for electric power plants, transport of buoyant effluents, water management issues associated with coal development, and environmental implications of ocean thermal energy conversion.

The Electric Utility Program encourages communication between the Energy Laboratory and electric utilities, especially those located in the northeastern United States. The program serves to inform participating utilities about ongoing MIT research activities, to identify and discuss utility needs and priorities, and to develop and coordinate research projects responsive to utility needs, both regional and generic.

The aim of the Nuclear Program is threefold: 1) to contribute to nuclear plant reliability and safety; 2) to develop and/or investigate possible improvements in plant design for fuel management that could lead to reduced power costs and more efficient utilization of nuclear fuel resources; and 3) to contribute to public understanding of nuclear power through communication of data and information.

PUBLICATIONS

During the past year, 176 publications resulted from research performed in the Energy Laboratory; these included 45 reports, 61 working papers, and 70 other publications (magazine articles, workshop and conference presentations).

DAVID C. WHITE
Laboratory for Nuclear Science

The Laboratory for Nuclear Science (LNS) provides support for research by faculty and research staff members primarily in the fields of basic nuclear and elementary particle physics, including the activities of the Center for Theoretical Physics in these fields. It also supports some projects involving application to other fields of experimental techniques developed in its primary activities, and 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, MA. The second area is high energy physics, with major projects at the Fermi National Accelerator Laboratory (FNAL) in Batavia, IL; at the Stanford Linear Accelerator Center (SLAC) in Palo Alto, CA; 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 (LBL).

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 nuclear physics where a major experimental program to study the properties of the atomic nucleus, using intermediate energy electrons and photons to generate a wide variety of reactions, is under way. MIT faculty, Bates staff physicists, and 67 user physicists from 30 other universities and laboratories in the US, Canada, Japan, and Europe, are presently engaged as initiators or collaborators in experiments there. A total of 22 MIT graduate students were associated during the past year with the intermediate energy nuclear physics programs.

The intermediate energy program at MIT continues to center around electron scattering experiments using the Bates high-precision electron scattering spectrometer. This unique spectroscopic facility is being applied intensively to a majority of the more than 40 experiments authorized for performance at Bates. The other experiments are directed primarily to studies of photon-induced pion and proton-emitting reactions. These are now being carried out with new facilities in the Laboratory's recently completed second experimental hall.

Further developments, which will extend both the accelerator's research domain and, together with the new experimental hall, its ability to meet the increasing requirements of users, are in progress. Construction has begun on a beam recirculation system which will increase the maximum beam energy to 750 MeV. The required building modifications and tunnel construction are in progress and the project is scheduled for completion in 1982. Development has continued, in collaboration with Yale University physicists, of a polarized electron beam source, which will open a new area of experimental investigation.

Another group in the intermediate energy nuclear physics area is collaborating with physicists at the BNL in a study of hypernuclei using a separated K meson beam in order to investigate the binding of Λ particles in nuclear matter. Data have been obtained which have allowed a detailed comparison with a nuclear model calculation. This group is also exploring jointly with physicists at Bell Laboratories the feasibility of constructing a detector which would measure both the flux and spectrum of low energy solar neutrinos.

Experimental High Energy Physics

During the fiscal year 1981, the Electromagnetic Interactions group has continued taking data with a large detector at PETRA, the e+e− colliding beam device at DESY. This experiment has confirmed quantum electrodynamics down to distances of 2 x 10⁻¹⁶ cm; has found evidence for the
existence of the gluon in three-jet events; and has measured the quark-gluon coupling constant. Measurements are being made of asymmetries produced by the electromagnetic and weak interference in the production of muon pairs. The group plans to continue the search for new leptons and new particles, analogous to the J., but made of heavier quarks when the beam energies are increased.

The Accelerator Physics Collaboration (APC) group 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 being used in a major experiment which will continue into 1982. They are also developing a new type of bubble chamber and holographic photography system to be used at the 1,000 GeV Tevatron being constructed at FNAL.

The Counter Spark Chamber (CSC) group is involved in a collaborative effort to construct a major new detector for high energy neutrinos at FNAL. The initial thrust of this apparatus will be the detailed study of the weak neutral currents predicted by gauge theories and discovered experimentally several years ago. The completed modules of the detector (which will contain 350 tons of instrumented material in addition to a large muon spectrometer) were successfully tested in 1981. The detector will be completed in 1982, at which time a several-year experimental program will begin.

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 BNL 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. The group has designed and is constructing a recoil mass selector for the Holifield Facility at the Oak Ridge National Laboratory, which they expect to use as a research tool in the future.

Applications of Nuclear Techniques

A group, in collaboration with teams from the Harvard Medical School, the Peter Bent Brigham Hospital, and the Massachusetts General Hospital, has been applying techniques of high energy in clinical medicine. A new detector, the mesh chamber, is being developed for three-dimensional imaging of positron emitting radioisotopes. Other projects include high pressure proportional chambers and gas scintillators for cardiac imaging, and a small proportional chamber imaging system for measurements of bone mineral loss.

Another group, in collaboration with Professor Alexander Rich of the Biology Department, has developed an X-ray diffraction facility for protein crystallography based on a wire drift chamber detector originally developed at CERN. Preparations for an initial crystallographic study are now in progress.

A scanning light ion microprobe has been developed by a member of the Heavy Ion group. It is utilized by MIT 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).

Particle Theory

It is presently believed that the particles which are at the basis of all matter are quarks and leptons, which interact with one another through gauge fields. There is currently a gauge field theory of the strong interactions called "quantum chromodynamics" (QCD) and another, the Weinberg-Salam theory, that unifies the electromagnetic and weak interactions. Both of these mathematical theories, which agree with experiments insofar as they have been tested, are being investigated by the particle theorists. Studies are also being made of "grand unified theories" which attempt to unify these two distinct gauge theories.
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 experimentally indicated permanent confinement of quarks in a hadron. These two
aspects of properties of quarks have for years been described by two complementary phenomeno-
logical models: the parton model and the MIT bag model, respectively, which are thought to be
approximations of QCD.

Some of the QCD-related topics studied during the past year are the following: a new bag model
of the pion, a model of the QCD vacuum including a gluon condensate and its spectrum, and the
phase structure and confinement aspects of gauge theories. In the area of the theory of electro-
magnetic and weak interactions, it was shown that masses can be generated spontaneously without
a Higgs field, and in a separate study, high mass states related to the $Z^0$ were predicted. Work
on grand unification models has led to predictions of the lifetime and the decay models of the pro-
ton and also to calculations of detailed cosmological phenomena which occurred at the very early
stages of the universe.

Nuclear Theory

The nuclear theory group has addressed a wide range of problems, including the interactions of
nuclei with mesonic and electromagnetic probes, the structure of nuclei spanning the periodic
table, and heavy ion reactions from below the Coulomb barrier to relativistic energies.

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. These investigations have improved our
understanding of collective phenomena and have been used to describe spontaneous and induced
fission.

A variety of projects are being pursued involving a QCD description of hadrons and the forces
between them within the context of the MIT bag model.

Pion nucleus elastic scattering is being studied in terms of isobar-nucleon hole collective doorway
states, with a complex isobar-nucleus interaction potential playing a central role.

A continuing program of inter-relating, semi-leptonic weak and electromagnetic interactions in
nuclear phenomena is being pursued.

Summary of Support

There were approximately 480 participants in the various research programs during the past year.
This includes 53 academic staff members, 98 graduate students, and at least 79 undergraduates
from MIT and other institutions. The latter were involved in senior theses, Undergraduate
Research Opportunities Programs, work-study, and similar programs. There were 80 research
staff members with Ph.D.s, including visitors and guests, and 171 employees in supporting
categories such as engineers, technicians, machinists, computing, and administrative personnel.
Over 67 active user physicists from 31 institutions participated in the program at the Bates Linear
Accelerator. At least five Ph.D.s, five S.M.s, and six B.S.s were awarded based on thesis
research within LNS.

Support during fiscal year 1981 from the contract with the US Department of Energy (DOE) is
expected to total $13,950,000, excluding the Bates recirculator construction project of $1,800,000
(fiscal year 1980 funds). This represents an increase of about 12 percent over the preceding
year. This sum breaks down as follows: operations costs (salaries, wages, materials, services,
travel, and overhead) were $10,735,000, of which $3,740,000 was for experimental and theoretical
high energy physics, $5,405,000 was for intermediate nuclear energy physics for the support of
the Bates Linac facility and program, and $1,590,000 was for nuclear structure theory, solar
neutrino, and heavy ion experiments. Equipment costs totaled $2,915,000, of which $1,915,000
was for high-energy physics and $1,900,000 was for medium energy and heavy ion physics. A
total of $300,000 will be expended for general plant projects associated with the Bates Linear
Accelerator. Support for relatively new Laboratory programs relating to the application of
Nuclear Reactor Laboratory

high-energy techniques to medical and biological problems totaled $200,000 (support came from the National Institutes of Health, the National Science Foundation, and DOE). Support for other programs within LNS, including support from other institutions and laboratories for collaborative work undertaken directly by LNS, totaled about $410,000.

JEROME I. FRIEDMAN

Nuclear Reactor Laboratory

During the past year the Nuclear Reactor Laboratory (NRL) engaged in joint activities with eight academic departments and three interdepartmental laboratories. The spectrum of these joint research or teaching and training activities include neutron scattering studies of condensed matter, nuclear materials research and development, radiochemistry and trace analysis applied to health effects of coal use, nutrition studies, earth and planetary sciences, nuclear medicine, reactor engineering, and training in reactor operations.

Overview

A major problem of investigation in the Neutron Diffraction Laboratory during the past year has been the study of the phase difference introduced to coherent beams within a neutron interferometer when the system is given small angular motion. It is known that the earth's rotation introduces an ever present phase difference of about one radian in the MIT interferometer, and the present experiments are designed to study the effects under controlled laboratory conditions for comparison with theoretical expectation. Various complications have arisen in the experiments, such as the need for sophisticated temperature control of the system on a millidegree centigrade scale and for vibration-free introduction of uniform angular motion.

Currently involved in this program are four graduate students in the Department of Physics, two working on doctoral thesis problems, and two on master's thesis problems. Collaborative support for the program has drawn upon effort from research faculty at Stonehill College and City College of New York. Support for the program of fundamental neutron physics has continued through the Department of Energy (DOE) and the National Science Foundation (NSF).

Other activities in neutron beam tube research included the Department of Nuclear Engineering's group of Professor Sow-Hsin Chen and Dr. Charles V. Berney. Significant instrument development was performed on the double-crystal spectrometer to improve energy resolution. A Ph.D. thesis by David R. Johnson is largely devoted to a description of this work. Experimental studies included the inelastic neutron-scattering study of crystalline formic acid and neutron-diffraction studies of graphite intercalation compounds. A master's thesis was completed by Zoran B. Djordjevic and several journal publications were produced. Future experiments will include further inelastic-scattering studies of molecular crystals and polymers, and studies of phase transitions in simple carboxylic acids. There is an ongoing Ph.D. thesis by Khaled A. Touqan on the subject of lattice dynamics of molecular crystals. The NSF has supported this research.

Professor Frederick A. Frey's group continued their studies in geochemical analysis. These projects are based upon use of the MTR-II for neutron activation analysis of rocks and minerals. Both radiochemical and instrumental activation are utilized to analyze for a wide variety of trace elements in this analytically oriented geochemical program. These projects continued to focus on improved understanding of the evolution and composition of the earth's mantle, the nature of the volcanic process creating new ocean floor at spreading ridge axes, such as the Mid-Atlantic Ridge, and the source and composition of volcanism occurring when oceanic plates collide with continental plates in regions such as the Andes Mountains.

These projects currently involve three to five graduate students, a full-time research staff person, and Professor Frey. Also, several other students use the NRL facilities for geochemical research on a part-time basis; i.e., activation analysis is not their major analytical approach. Recently, funding has been obtained for a computer-based activation analysis system. This system is now being installed and is expected to significantly upgrade the capabilities for nuclear trace analysis.
The Medical Research group of Professor Gordon L. Brownell in the Department of Nuclear Engineering has continued the development of boron neutron capture therapy for treatment of glioblastoma. This brain tumor is extremely difficult to treat by other means, and an effective form of therapy would be a major breakthrough. The present study is aimed at demonstrating the efficacy of the technique using a beagle neonate brain tumor model. The results are encouraging, and plans for clinical application in patients are being formulated. The project consists of physical studies on neutron penetration and dosimetry and biological studies on the effects of radiation. Several doctoral students are working on this project. There is close collaboration between investigators in a number of medical centers.

Medical isotope production and development for a variety of purposes was continued. Development work on short half-lived (low dose) imaging isotope $^{191}$Os-$^{191m}$Ir was continued as a student research project under the direction of Dr. Salvadore Treves, Children's Hospital; Professor Alan Davison, Department of Chemistry; and Professor Otto K. Harling and Dr. Barry W. Wessels of the NRL. This generator looks particularly promising for diagnostic imaging where it may be desirable to obtain repeated images at short time intervals.

Other isotopes were routinely produced in support of medical research programs, including $^{165}$Ho for synovectomies and $^{198}$Au for cancer therapy. A new project was initiated to produce Fluorine 18 which, because of its nuclear and chemical properties, is potentially of great usefulness in a wide variety of medical applications.

Dr. Wessels, a senior researcher, was hired to coordinate and lead the NRL activities in nuclear medicine and other life science applications of the MITR-II.

During the past year the Radiochemistry and Nuclear Trace Analysis group under Dr. Mortezan Janghorbani has continued a very active series of projects in several multidisciplinary areas.

The area of stable isotopes in human mineral nutrition was originally established in 1978 as an exploratory venture with the Department of Nutrition and Food Science in collaboration with Professor Vernon R. Young. Due to the unique combined capabilities of the NRL in regard to stable isotope methodology and the Department of Nutrition and Food Science and the Clinical Research Center with respect to the conduct of human metabolic studies, MIT is now a national leader in this area of human nutrition. Since inception of this program less than three years ago, the MIT group has produced some 20 publications in various scientific journals, including four invited contributions at major national and international conferences. The group has continued to receive funding from such Federal agencies as the National Institutes of Health, the National Science Foundation, and the United States Department of Agriculture, as well as several industry sources. The program has led to development of collaborative research between MIT and several US and foreign universities and research organizations. Currently, this group consists of three faculty members from the Department of Nutrition and Food Science (Professors Young, Noel W. Solomons, and Nevin H. Scrimshaw), three full-time research staff from the NRL, one guest scientist, six full-time MIT graduate students (S.M. and Ph.D. candidates), and several part-time associates.

The Radiochemistry group is continuing research on three other projects in which Dr. Janghorbani acts as the principal investigator. These programs are concerned with: trace element uptake in the marine food chain (National Oceanic and Atmospheric Administration-Sea Grant), measurement of halogens in the stratosphere (US Air Force), and development of tracer techniques for use in the study of ocean dispersion of drilling fluids (NOAA). The Radiochemistry group also continues to collaborate on the coal research program of Professor Adel F. Sarofim, Department of Chemical Engineering, in which two Ph.D. students are currently involved. The facilities and expertise of the group are also called upon periodically on an Institute-wide basis to assist in other research programs.

A major alloy development project for fusion reactor first wall materials was continued for the third year. This research is directed by Professor Nicholas J. Grant of the Department of Materials Science and Engineering, and Professor Harling. Other faculty participants were Professors Kenneth C. Russell and John B. Vander Sande of the Department of Materials Science and Engineering, Professor John E. Meyer of the Department of Nuclear Engineering, and Professor Ali S. Argon of the Department of Mechanical Engineering. Senior research staff on this project included Drs. Janez Megusar, Lars Arnberg, Harold J. Frost, and Nasser Kanani. Two graduate
students completed their Ph.D. dissertations and one completed an S.M. with research done on this project. About 15 journal articles have been completed to date as a result of activities in this project.

A major thrust of this research effort is to explore the use of innovative alloy processing techniques, such as rapid solidification from the melt, to develop primary first wall alloys for the fusion reactor first wall applications. The development of improved first wall alloys is on the critical path toward economical fusion power. The MIT approach provides a means to manipulate alloy micro-structure and micro-chemistry in order to beneficiate irradiation performance. Alloy design, alloy production, irradiation testing, and post irradiation characterization are the major parts of this interdisciplinary project. Special facilities for handling and testing radioactive materials have been developed at the NRL to meet the needs of this research. Graduate student involvement in all project phases, including irradiation testing and irradiated material characterization, offers unique training for MIT students involved in this research.

Another nuclear materials research project is an in-reactor irradiation experiment at the MITR-II. This experiment is designed to assess the performance of typical fusion reactor materials during operation as part of the fusion reactor first wall. In this sophisticated test, the metal alloys are subjected to stress and temperature cycles, alpha particle bombardment, and fast neutron irradiation, all simultaneously. This work is under the direction of Professor Harling. Other faculty are Professor Argon, and Professor I-Wei Chen, Department of Nuclear Engineering. Two students, one a candidate for an S.M., and the other a Ph.D. candidate, are carrying out their thesis research on this project.

Other research activity included: 1) development of a uranium assay capability for a research project on uranium concentration in sea water, by Professor Michael J. Driscoll's group, Department of Nuclear Engineering; 2) research support under the Federally funded Reactor Sharing Program for several local and regional universities; 3) the Reactor facility served as a demonstration site for testing electronic surveillance systems for the Arms Control and Disarmament Agency under US Department of State auspices; and 4) a research effort aimed at demonstrating reactor control by computer was continued under the direction of Draper Laboratory staff and Professor David L. Lanning, Department of Nuclear Engineering.

Twenty-five years ago this past June, ground was broken for the MIT Research Reactor at 138 Albany Street. Except for two years of construction during 1956-58 and another year for upgrading and overhaul in 1974-75, the Reactor has operated pretty much routinely since 1965 at its design power level of 5 MW. During the past year it continued its usual Monday through Friday operating schedule, averaging 88 hours per week at full power, holiday weeks included. Last April 30th the MITR-II, as the upgraded Reactor is now called, generated its 100,000th megawatt-hour of energy output. The MITR-I generated 250,445 MWH from 1958 to 1974. As the cost of oil continues to rise, new studies have been initiated to determine if the low grade heat output of the Reactor (130° F. or less) can be economically used for heating buildings at MIT. Potentially a large fraction of the Institute's heat load would be provided by waste Reactor heat.

The numerous Reactor facilities are increasingly utilized, although still more experiments can be accommodated. While there has been some increase in use of the medical facilities, the principal expansion has occurred in the activation of materials for the Trace Analysis Laboratory. For this and the other activities described above, the total irradiations during the year jumped to 5,973, considerably more than double the 2,350 irradiations for the previous year. The increase was facilitated by extensive use of the relatively new automated rabbit system for sending and receiving specimens at the radiochemistry laboratories in Building NW13. The recently installed hot cell inside the containment building also performed well. A perchloric acid hood, the only approved such hood at the Institute, was installed in Room NW12-138, and it is now in use for the preparation of electron microscope specimens of irradiated materials. The Reactor license was amended by the Nuclear Regulatory Commission to authorize receipt and use at NRL of radioactive specimens irradiated in the high-flux reactors at national laboratories and other facilities. The Reactor as a whole has been utilized during the year by the Charles Stark Draper Laboratory as a typical source of reactor process signals that would be analyzed by fault-tolerant computers developed for the space program to aid reactor operators in nuclear power plants to assess rapidly the reliability of data displayed on control room instrumentation.
The US Department of Energy (DOE) continues to supply reactor fuel to MIT, as it does to other universities operating reactors for research and training purposes. Fuel management studies employing sophisticated reactor physics computer programs have resulted in very economical use of the fuel, some of it remaining in the reactor core for more than three years of operation. Consumption is thus only about 10 elements per year, depending upon the operating mode and schedule.

Reactor operations activities continue to provide first-rate training for four to six MIT students who are typically part of the operation's staff.

The NRL's supporting craft services have now grown into a relatively large activity with full-time staff. Most of the work performed by these craftsmen, greater than two-thirds, is for other research centers and academic departments. Services which are provided include machining, welding, mechanical design, electronics, and management of craft work when it is performed for MIT by outside vendors.

Currently there are two major research thrust areas being developed at the NRL. These are: 1) applications of the MITR-II in life sciences, and 2) neutron scattering. In both areas a key ingredient in developing the new activities and capabilities is the acquisition of highly qualified senior staff. This step has been accomplished for area 1 and will continue to be pursued in the coming year for area 2.

OTTO K. HARLING

Patent, Copyright and Licensing Office

Patent Trends

The Uniform Patent Legislation is now law effective July 1, 1981, (PL 56-517). This Act significantly changes the government/university relationship in the area of patent licensing. Under the new Act, which applies to substantially all (with some specified exceptions) research agreements executed from July 1 on between the Federal government and the Institute, title to inventions made in the course of such sponsored research vests from the outset in the Institute, eliminating the need for specific patent agreements with and/or waiver requests to each government agency. The Act permits exclusive licensing for the life of the patent to small business firms and limited-term exclusives to other licensees. It also contains a new provision which has no precedent in government/contractor patent relationships. Specifically, universities may not grant an exclusive license to a United States patent unless the licensee agrees that any products embodying the invention or product thereof will be manufactured substantially in the United States. This is a clear preference for US industry and is an attempt to encourage technological developments and product manufacturing within this country.

A major impact of this Act on universities will be the requirements for reporting of inventions to the sponsoring agencies. The implementing regulations which include detailed reporting requirements are being reviewed by this Office, and comments will be forwarded to the Office of Federal Procurement Policy by September 1, 1981.

Another piece of legislation which should impact on the Institute's patent program is the Patent Term Restoration Act. This Act effectively restores to the patent owner the number of years lost (up to 10) while the invention is involved in regulatory processing. For example, if the Federal Drug Administration (FDA) review process of a particular product takes five years, this time period would be added to the life of the patent to extend it for the additional time period. The bill has received strong support from the university community. This Office testified before the Committee on the Judiciary (US Senate) in favor of the proposal.
Patent Marketing

Disclosures and Licensing

During the past fiscal year, 156 invention disclosures were received, 90 US patent applications were filed, and 50 US patents issued. Additionally, 78 patent applications were filed in foreign countries corresponding to 12 US applications. Gross royalty income from patent and copyright licensing totaled $1,607,781. In addition, industry committed approximately $183,000 in the form of research funding which is directly attributable to the licensing program, as this research support is in conjunction with option/license agreements to inventions. Licensing efforts during this past year have concentrated in the general areas of medical/biological applications; energy-saving products; metallurgical process; and data communications. A significant effort continues to be expended in working with the Office of Sponsored Programs in the negotiation of sponsored research agreements with industry.

Personnel

During this past year, two attorneys were hired to fill the two vacancies in the Office caused by resignations.

ARTHUR A. SMITH, JR.

Patent Marketing

During the past year, the patent marketing effort has been directed toward three areas in order to improve efficiency and increase responses by prospective licensees. First, the invention portfolio has been critically reviewed and reclassified into a larger group of topic areas than originally used in the MIT Licensing Opportunities book. The current invention descriptions, grouped in the new categories, have been reprinted and distributed according to customer interests.

Second, the assistance of individual inventors was solicited through a questionnaire to improve the invention descriptions. In particular, abstracts were rewritten to emphasize the commercial incentives each invention offers.

The third step was to begin automation of mailing new invention abstracts to prospective licensees. This was undertaken in cooperation with the Industrial Liaison Program (ILP), whose computer services are being employed.

In addition to circulating MIT's invention portfolio by mail, the inventions were displayed at a booth at Tech Ex'81 in Atlanta where over 200 contacts were made. In addition, the patent abstracts are disseminated through Control Data Corporation's Technotec data base, and the computer search services of Dr. Dvorkovitz and Associates and General Electric. Finally, an ILP symposium on solar cell technology was conducted to highlight the large number of inventions made at Lincoln Laboratory in the areas of solar cells and semiconductor device fabrication techniques.

BRUCE D. WEDLOCK

Plasma Fusion Center

During the past year there has been significant technical progress in the Plasma Fusion Center's (PFC) research programs. Outstanding technical excellence is the primary cornerstone of all PFC research activities, and a major emphasis is placed on providing the intellectual environment that fosters independent creativity, both at the individual researcher level and on the scale of major fusion projects such as the Alcator C tokamak and the TARA tandem mirror. An important strength of the Plasma Fusion Center, and more broadly speaking, of MIT as an institution, is the ability to evolve new ideas and concepts in critical physics and technology areas required for
Vice President, Research

development of fusion energy, and to train professional researchers. The Plasma Fusion Center
technical programs are supported by the Department of Energy’s (DOE) Office of Fusion Energy.
During the past year, the funding level has been approximately $14.7 million. Approximately
230 technical personnel are associated with Plasma Fusion Center research activities. This
includes: 25 faculty members (with participating faculty from the Departments of Aeronautics and
Astronautics, Electrical Engineering and Computer Science, Materials Science and Engineering,
Mechanical Engineering, Nuclear Engineering, and Physics), more than 95 research scientists
and engineers, 65 graduate students, and 45 technical support personnel. At the present time,
the PFC’s major experimental and engineering facilities are located at several sites on the MIT
campus, including NW16 (Plasma Fusion Center), NW20 (PFC 220 MW Alternator), NW21 (PFC
Nabisco Laboratory), NW13 (Nuclear Engineering), NW14 (National Magnet Laboratory), Building 36
(Research Laboratory of Electronics), and Building 38 (Electrical Engineering and Computer
Science).

ALCATOR CONFINEMENT EXPERIMENTS

The Alcator experimental program constitutes one of the most successful and prominent tokamak
confinement programs, both nationally and internationally. The primary objective of the Alcator
experimental program, headed by Professor Ronald Parker, is to develop the basic physics under-
standing of the stability, transport, and radiation properties of high-temperature plasmas at
near-reactor conditions and to develop methods for heating plasmas to fusion temperatures. The
main Alcator experimental areas include: equilibrium, stability, and operations (Professor Parker);
confinement studies (Dr. Stephen Wolfe); plasma-wall interactions (Dr. Earl Marmar); and radio
frequency heating (Professor Miklos Porkolab and Dr. Jack Schuss). The main Alcator design
area during the past year includes Alcator A modification (Drs. Peter Politzer and D. Bruce
Montgomery). Professors Parker and Bruno Coppi are overall Alcator program principal investi-
gators.

Alcator A

The Alcator A is a relatively small (minor radius = 10 cm, major radius = 54 cm) tokamak which is
able to operate at extremely high toroidal field strengths (up to 100 kG). During the past year,
research activities on Alcator A have been curtailed, as the primary emphasis of the experimental
program has focused increasingly on the operation of the larger, higher field tokamak Alcator C.
Alcator A has operated for nearly nine years and has proved to be one of the most important and
successful fusion experiments in the world during the decade of the 1970s. While Alcator A is
principally known for the discovery of an empirical scaling law that relates energy confinement
time to plasma density, a result which was exploited to raise the Lawson product nT by an order
of magnitude, many equally significant technical results have been obtained in several key areas.
Among recent important results are basic contributions to impurity control and confinement,
methods of particle removal and control, and development and testing of techniques for RF heating.
These areas of research are critical for the continued development of the tokamak concept for use
as a fusion reactor, and research on these problems is being continued on Alcator C as well as
tokamaks at other laboratories.

Alcator C

The Alcator C tokamak (major radius = 64 cm, minor radius = 16 cm, toroidal magnetic field up to
140 kG) has been operated intensively during the past year with particular emphasis on the study
of ohmically heated discharges at toroidal fields up to 100 kG. The "best" parameters produced
in the Alcator C device during this period are line averaged density \( n = 7 \times 10^{14} \text{cm}^{-3} \), electron
and ion temperatures of 3 keV and 1.6 keV, respectively, plasma currents of 600 kA, and energy
confinement times of approximately 35 ms.

Although Alcator C has performed up to design expectations in most areas, an exception has been
in the measured value of energy confinement time \( \tau_E \). The best value obtained for \( \tau_E \) is about a
factor of two below that anticipated on the basis of extrapolation of the results from Alcator A.
This can be traced to the observed dependence of \( \tau_E \) as a function of plasma density. At plasma
densities in excess of $2 \times 10^{14} \text{cm}^{-3}$, it has been found that $\tau_E$ increases only slowly with density rather than continuing to increase linearly with density as found in Alcator A. The main results are consistent with an enhanced (anomalous) ion energy transport that is up to a factor of five times larger than the classical value based on two-body collisions. However, the present experimental uncertainties are such that a departure from an empirically based scaling law for electron thermal conductivity could also explain the trends in the data. The main significance of these results is that the ion energy confinement time at high densities may be less than expected. This will make the achievement of $n_T \tau_E = 10^{14} \text{sec-cm}^{-3}$ difficult in Alcator C. However, the present best value of $n_T \tau_E = 3.5 \times 10^{13} \text{cm}^{-3}\text{-sec}$ obtained in Alcator C does exceed that obtained in Alcator A, and a value of $n_T \tau_E = 5 \times 10^{13} \text{cm}^{-3}\text{-sec}$ is expected to be achieved in Alcator C even with the unfavorable trends discussed above. These experimental studies are receiving continued emphasis with expanded and more accurate diagnostic capability.

**RF-Heating**

The second phase of the Alcator C experimental program, the use of high-power radiofrequency (RF) waves to raise the plasma temperature, has begun with the installation of a single four-waveguide coupler operating at a frequency of 4.6 GHz. This unit will enable a maximum of 250 kW to be applied to Alcator C plasmas. During the coming year, more RF tubes and couplers will be added and this will result in an ultimate capability of 4 MW using a total of 64 waveguides. Present low-power studies are concerned with matching the plasma to the RF system, studies of wave propagation effects, and at higher power levels, plasma heating. Significant technological progress has been made during the past year on the development of the RF couplers and vacuum windows.

**Alcator A Modification**

A design effort concerned with modifying the Alcator A device and summarized in last year's report has been expanded and continued. The primary objective is the development of an experimental facility for the basic study and control of MHD instabilities and disruptions. The important feature of the design is a helical $Z = 2$ winding capable of producing substantial vacuum rotational transform. Combining this winding with those of a conventional tokamak leads to a device with considerable flexibility in its modes of operation, ranging from operation as a pure tokamak to operation as a pure stellarator, with an intermediate "hybrid" mode that has both tokamak and stellarator features. The present design (minor radius = 30 cm, major radius = 110 cm) is approximately twice the size of Alcator C but has considerably lower toroidal field capability (up to 30 kG). An advantage of the increased size and lower design field is the availability of substantially increased access, which will be exploited both for additional diagnostics and RF heating capability.

**MIRROR CONFINEMENT EXPERIMENTS**

The Plasma Fusion Center and MIT have made a strong institutional and intellectual commitment to the establishment of a center of excellence for mirror systems fusion research at MIT. In this regard, Drs. Richard S. Post and Jay Kesner have accepted appointments at MIT to initiate a tandem mirror experimental program that will significantly complement the mirror research activities at Lawrence Livermore Laboratory (LLNL) as well as the ongoing PFC research activities in mirror theory and the Constance II experimental program.

In the fall of 1980, the Mirror Confinement Systems division, headed by Dr. Post, prepared a technical proposal to DOE for construction and operation of a major new tandem mirror experimental facility called TARA. The TARA proposal received very strong technical endorsement by a peer review panel chaired by Dr. Grant Logan of LLNL. The construction costs for the TARA device are approximately $13M over a 30-month period, with initial operations beginning in fall 1983. The principal investigators are Drs. Post and Kesner, and the TARA device will be sited in the west wing of the Nabisco Laboratory.

The TARA device will be a medium-sized tandem mirror, with plasma parameters that are comparable to the Tandem Mirror Experiment (TMX) at LLNL, during its initial phase of operation ($T_i - T_e = 0.1 \text{keV}$), and plasma parameters $T_i - T_e = 0.4 \text{keV}$ and $n \tau = 2 \times 10^{11} \text{sec-cm}^{-3}$ in full operation.
The principal features of the TARA design include axisymmetric central-cell confinement, high mirror ratio ($R = 6$), thermal barriers, and a low-field quadrupole anchor to provide MHD stability. The experiment will test the advantages of axisymmetry in tandem mirror confinement, beta limits, and microstability. The experiment will also incorporate central-cell startup, neutral beam fueling, and RF heating in the electron cyclotron and ion cyclotron range of frequencies. Additional experiments will be performed on the feasibility of hot electron anchors for obtaining MHD stability.

On April 7, 1980, Nabisco, Inc., with headquarters in East Hanover, NJ, conveyed its property at 184–190 Albany Street, Cambridge, MA, to MIT. The estimated value of the 71,000 square foot building and property is in excess of $1.5 million. This facility, now designated as the Nabisco Laboratory (NW21), is adjacent to the PFC 220 MS Alternator (NW20) donated by Consolidated Edison Co. of New York, and PFC research facilities located in the Francis Bitter National Magnet Laboratory (NW14), the Department of Nuclear Engineering (NW13), the Nuclear Reactor Laboratory (NW12) and the PFC office facility (NW16). The proximity to these facilities and heavy power make the Nabisco Laboratory an ideal location to house the Plasma Fusion Center's major confinement experiments and engineering test facilities. Currently proposed to DOE is a $2.2 million renovation of the west wing of the Nabisco Laboratory. This space will contain a 4,000 square foot experimental bay for the TARA tandem mirror, along with 11,000 square feet of support shops, laboratory setup space, and power rooms. Phase I renovations are expected to be completed early in 1983. The east wing of the Nabisco Laboratory is under construction as the site for the Alcator A modification experiment.

APPLIED PLASMA PHYSICS RESEARCH

The primary objective of the Plasma Fusion Center 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. Present applied physics research activities include: experimental research on the Versator II tokamak (Professors George Bekefi, Porkolab, and Dr. Stan Luckhardt); experimental research on the Constance II mirror device (Professor Louis Smullin); fusion theory and computations (Professors Abraham Bers, Coppi, Davidson, Dupree, Jeffrey Freidberg, James McCune, and Kim Molvig); development of the MACSYMA symbolic manipulation system (Professor Joel Moses); plasma diagnostics development (Dr. Daniel Cohn, Professor Benjamin Lax, and Dr. Paul Woskoboinikow); development of advanced fusion concepts (Professor Lawrence Lidsky and Dr. Politzer); basic experimental and theoretical research on intense charged particle beams (Professors Bekefi and Davidson).

We summarize here the significant progress made during the past year in selected applied plasma physics research areas.

Versator II is a medium-sized research tokamak (major radius = 40.5 cm; minor radius = 13 cm; toroidal magnetic field = 15 kG) with primary emphasis on basic investigations of plasma heating and confinement properties. Lower-hybrid, current-drive experiments on Versator II have drawn significant national attention during the past year. In particular, it has been shown that in the vicinity of the lower hybrid frequency it is possible to enhance the toroidal current by injecting unidirectional lower hybrid waves via a set of 4- or 6-phase array of waveguides, thus imparting a net toroidal momentum to the plasma electrons. By injecting 30–50kW of RF power at a frequency of 800 MHz, a net current increase of up to 15 kA has been observed, implying an RF-generated current of 25–30 kA. Thus, in these experiments, most of the toroidal current is due to the injected RF power rather than the initial ohmic heating current (approximately 30 kA). These results show that an RF driven steady-state fusion reactor might be possible. However, contrary to present theory, the current-drive mechanism operates only at relatively low plasma densities ($n_0 < 10^{13} \text{cm}^{-3}$), whereas a reactor would operate at densities in excess of $10^{14} \text{cm}^{-3}$. Ways to increase the density limit are presently under investigation, as well as the detailed physical mechanism responsible for RF current drive. The Versator II current-drive experiments are perhaps the most advanced and best diagnosed in the world. Future plans include the lengthening of the RF pulse, and crowbarring the ohmic heating supply to study the equilibrium and stability properties of a fully RF-driven tokamak. In parallel with the above experiments, studies of electron cyclotron resonance heating (ECRH) are under way in collaboration with scientists from the Naval Research Laboratory (NRL). ECRH power at a frequency of 35 GHz and 100 kW is injected into the Versator II tokamak using the NRL gyrotron as the microwave source. Preliminary results show electron heating with an efficiency in excess of 60 percent. Combined ECRH and lower hybrid current-drive experiments will be carried out in the near future.
Constance II is a moderate-sized mirror research facility with primary emphasis on the basic experimental development of RF and beam-plasma techniques for stabilization of mirror loss-cone instabilities. During the past year, the Constance II mirror facility has been improved by the development of a new hot-cathode plasma gun that generates hotter and denser plasmas than the washer guns used previously. The guide field strength has been increased from 1.8 kG to 2.8 kG by adding eight coils taken from the Constance I experiment. Moreover, a Thomson scattering diagnostic, including laser and five-channel polychromator, has been fabricated and calibrated, and is now being installed on Constance II. Theoretical and numerical studies are being carried out in a variety of areas: nonadiabatic particle motion in a minimum-B mirror; ray tracing for microwave power at the electron cyclotron resonance frequency; and the excitation of transverse modes in a warm plasma by a density modulated electron beam. Wall effects, such as lowering of the plasma electron temperature by secondary electrons, are being studied. Measurements of secondary electron emission from gas-covered metal targets show anomalously high values compared to clean surfaces.

In the plasma theory and computations area, there has been considerable technical progress during the past year in a variety of important areas. Recent studies include: a) the development of a self-consistent plasma model which simultaneously includes the effect of neoclassical transport and plasma turbulence; b) the continued development of self-consistent theoretical models describing anomalously high electron energy transport in tokamaks; c) basic investigations of the MHD stability properties of tokamak plasmas and the determination of stable operating regimes at moderate values of plasma beta (the ratio of plasma pressure to magnetic pressure); d) the development of a self-consistent kinetic description of the free electron laser instability including the important influence of finite radial geometry; e) continued basic theoretical investigations of RF heating, including studies of steady RF current drive and computational studies of the nonlinear coupling of microwave power to the plasma from waveguide arrays; f) studies of the thermal stability of ignited plasmas; g) basic studies of the MHD stability properties of toroidal fusion systems with external helical windings; h) fundamental nonlinear studies of the influence of stochastic magnetic fields on turbulent transport in high-temperature plasmas; and i) basic studies relating to the equilibrium, stability, and transport properties of high-field tokamak configurations using advanced fuels (e.g., D-He³).

MACSYMA is a symbolic manipulation program implemented on the MACSYMA consortium PDP-10 at MIT and available to the magnetic fusion community through the National Magnetic Fusion Energy Computer Network. The MACSYMA effort involves 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. A new project is under way to develop a LISP system, called NIL, which is exportable and can support MACSYMA on recently available large-address machines such as DEC VAX-11. In addition to the ongoing algorithm development for the symbolic manipulation of algebraic structures, an effort has also been initiated to implement improved I/O facilities such as a two-dimensional display editor for mathematical expressions.

In the area of advanced fusion concepts, there has been a continued emphasis on the development of fusion reactor designs consistent with the best available models of plasma physics and technological capabilities. Torsatron research activities during the past year have included studies related to ion thermal conductivity and alpha-particle transport, as well as investigations of modular coil structures.

FUSION TECHNOLOGY AND ENGINEERING

The Fusion Technology and Engineering division, headed by Dr. Montgomery, provides engineering support for the advanced design projects, and develops advanced superconducting magnet technology for the national fusion program. Research activities include: advanced design for the proposed Alcator A modification experiment and for the proposed Garching high-field ignition test experiment; responsibility and design support for the magnet systems of the Fusion Engineering Device (Joel Schultz and Dr. Roger Derby); responsibility for construction of a magnetic divertor for the ISX-B tokamak at Oak Ridge National Laboratory (ORNL); and responsibility to develop improved magnetic divertor concepts (Dr. Ted Yang), the development of forced-flow superconductors for application to advanced fusion devices (Mitchell Hoening); and 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.

The next major step in the US fusion program will be a 200 MW output, 100-second-burn engineering tokamak device presently known as the Fusion Engineering Device (FED). A six-member technical management board, of which Dr. Montgomery is a member, has been established by DOE to develop the overall concept and objectives for the device, and to develop a parallel engineering feasibility program to supplement the FED and prepare for the first demonstration fusion reactor.

The Plasma Fusion Center was selected by DOE to take responsibility for the magnetics branch of the FED Design Center activities. This work is carried out in close cooperation with the Fusion Engineering Design Center headquarters at ORNL, which has overall responsibility for systems integration and management of FED design activities. Dr. Derby, MIT magnetics branch manager at ORNL, is responsible for coordinating the design work done by General Electric, the industrial magnetics contractor, and the support magnetics design work at the Plasma Fusion Center and elsewhere in the country. The superconducting magnet systems will be an order-of-magnitude larger than any current projects and hence represent the most demanding magnet design project ever undertaken.

The Plasma Fusion Center has been active in developing improved magnetic divertor concepts under the direction of Dr. Yang. A long-burning fusion reactor must deal with the buildup and removal of helium "ash" and impurities, and magnetic or mechanical divertors are considered to be an extremely demanding but necessary component. The Plasma Fusion Center has recently completed the major construction of a high-field divertor for the ISX-B tokamak at ORNL. The ISX-B divertor will be installed in September 1981. Professors Borivoje Mikic and Neil Todreas and their students have been active during this academic year working with Dr. Yang on basic divertor studies.

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 coil for the Large Coil Project at ORNL. The group will also utilize an advanced version of the conductor to build a 40 cm bore, 12 tesla insert for the High Field Test Facility at the Lawrence Livermore Laboratory.

Basic research on advanced superconducting materials is also a major fusion engineering activity in the Plasma Fusion Center and the Department of Materials Science and Engineering. The objective is to develop materials and techniques for producing superconductors capable of generating 15 tesla magnetic fields, and sufficiently ductile to be suitable for advanced fusion devices. Materials developed by this group show considerable improvements in mechanical properties and offer a significant possible reduction in production costs over conventional industrial preparations.

FUSION SYSTEMS

The Fusions Systems division, headed by Dr. Cohn, investigates several aspects of fusion reactor design and develops advanced millimeter and submillimeter wave technology. Research activities include: safety and environmental studies (Professor Mujid Kazimi); reactor system studies (Dr. Cohn); blanket and first-wall structural design studies (Professor John Meyer); gyrotron and advanced millimeter source development (Dr. Richard Temkin); and millimeter and submillimeter detector development (Drs. Harold Fetterman and Peter Tannenwald, Lincoln Laboratory).

During the past year, there has been significant progress in these activities, and we summarize here progress in a few selected areas.

In the safety and environmental studies area, lithium fire risk has been investigated for various tritium breeding blanket designs. A total energy cycle assessment of fusion power production also has been made. Future activities will include studies of risk in non-metal cooled reactors and improved modeling of lithium fires.
The reactor system studies group has developed concepts for the operation and control of ignited (self-heated) plasmas and has completed a conceptual design of a compact tokamak ignition test reactor (ITR). The ITR design was carried out in collaboration with the Max Planck Institute for Plasma Physics at Garching, Federal Republic of Germany. Research activities have been initiated on the study of tokamak reactors with stabilizing helical coils, improved stellarator reactor designs, and the design of high-performance resistive magnet tokamak reactors for advanced fuel cycle operation. New aspects of the use of fusion neutrons for breeding fissile material will also be investigated during the coming year.

In the gyrotron development area, theoretical studies of threshold and cavity design effects in high-frequency (~140 GHz) devices have been carried out. A special gun for high-frequency gyrotron operation has been designed in collaboration with Varian Associates, and an experimental study of high-frequency gyrotron operation will be initiated during the coming year.

In the area of plasma diagnostics development, a very sensitive submillimeter wave heterodyne receiver has been used for new measurements of cyclotron emission from Alcator A and Alcator C. This detector system together with a high power, 385 μm D₂O laser will be employed for ion temperature measurements on Alcator C.

APPOINTMENTS AND PROMOTIONS

During the past year, there have been several important appointments and promotions in Plasma Fusion Center program areas:

Appointments include: Dr. Teymour Boutros-Ghali (MIT), appointed assistant visiting professor of Nuclear Engineering in Plasma Theory; Paul Brindza (University of Michigan), appointed project engineer responsible for TARA machine operations; Dr. John W. Coleman (MIT), appointed research scientist in the TARA neutral beam development program; Dr. Robert Estes (University of Texas), appointed research scientist in the free electron laser theory program; Dr. Catherine Fiore (Rensselaer Polytechnic Institute), appointed research scientist in the Alcator confinement program; Dr. David H. Griffin (Lawrence Livermore Laboratory), appointed RF electrical engineer in the Alcator program; Mitchell Hoening (MIT), appointed research scientist in the superconducting magnet development program; Christopher Hume (Digital Equipment), appointed systems programmer and analyst in the Alcator confinement program; Carl Karcher (University of Wisconsin), appointed data systems engineer in the TARA confinement program; Dr. Robert Estes (University of Texas), appointed research scientist in the free electron laser theory program; Dr. John W. Coleman (MIT), appointed research scientist in the TARA confinement program; Dr. Catherine Fiore (Rensselaer Polytechnic Institute), appointed research scientist in the Alcator confinement program; Mitchell Hoening (MIT), appointed research scientist in the superconducting magnet development program; Christopher Hume (Digital Equipment), appointed systems programmer and analyst in the Alcator confinement program; Carl Karcher (University of Wisconsin), appointed data systems engineer in the TARA confinement program; Dr. Kenneth Kreischer (MIT), appointed postdoctoral associate in the charged particle beam program; Richard Lawhorn (MIT), appointed systems programmer and analyst in fusion theory and computations; Richard Lawhorn (MIT), appointed systems programmer and analyst in fusion theory and computations; Dr. Wayne McMullin (University of California at San Diego), appointed postdoctoral associate in the charged particle beam program; Dr. Brian McVey (University of Wisconsin), appointed research scientist in the TARA RF heating development program; Dr. Albert Montgomery (MIT), appointed research scientist in the superconducting magnet development program; Donald Nelson (MIT), appointed computer systems manager in the Alcator confinement program; David C. Plummer (MIT), appointed systems programmer and analyst in fusion theory and computations; Donald Nelson (MIT), appointed research scientist in the TARA RF heating development program; Dr. David Tetreault (MIT), appointed research scientist in fusion theory and computations; Dr. Kim Theilhaber (MIT), appointed postdoctoral associate in fusion theory and computation; and Alex Theodorou (MIT), appointed data systems engineer in the Alcator confinement program.

During the past year, Institute research promotions in the Plasma Fusion Center include: Dr. Peter Politzer promoted to principal research scientist in the Alcator confinement program; Dr. Jay Kesner promoted to principal research scientist in the TARA tandem mirror program; and Dr. Jack Schuss to principal research scientist in the Alcator confinement program. In addition, Dr. Kim Molvig has been promoted to associate professor of Nuclear Engineering in Plasma Theory.

Internal Plasma Fusion Center promotions to division head, group leader, and associate group leader positions of major programmatic responsibility include: Dr. Richard S. Post, head, Mirror Confinement Systems Division; Dr. Jack Schuss, assistant leader, Alcator RF Heating Group; and Dr. Stephen Wolfe, leader, Alcator Confinement Studies Group.
During the past year, there have been several new visiting scientists and engineers in Plasma Fusion Center program areas. These include: Dr. Gerhardt Berge (University of Bergen), MHD stability of fusion plasmas; Dr. Christine Celata (Dartmouth College), radiation properties of the Versator tokamak; Dr. Vincente Colomer (University of Cordoba), lower hybrid diagnostics on the Versator tokamak; Dr. George Johnston (Lawrence Berkeley Laboratory), theory of free electron lasers; Dr. Jerrold Levine (NRL), electron cyclotron heating on the Versator tokamak; Dr. Michael Read (NRL), electron cyclotron heating on the Versator tokamak; and Dr. Hong Zhang (Shanghai Institute of Metallurgy, Chinese Academy of Sciences), development of ductile 15 tesla superconducting materials.

RONALD C. DAVIDSON

Research Laboratory of Electronics

The Research Laboratory of Electronics (RLE), established at the end of World War II, was the Institute's first interdepartmental laboratory. In the years since, it has evolved into an on-campus research environment which provides faculty members and their students with the diverse services and facilities of a large laboratory. RLE 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 RLE is primarily performed by faculty members, postdoctorals, 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, three engineer's, 15 master's, and 23 bachelor's degrees.

Major support for the research is provided by the Joint Services Electronics Program of the Army, Navy, and Air Force, as well as other agencies of the Department of Defense (DoD), the Department of Energy (DOE), the National Science Foundation (NSF), the National Institutes of Health (NIH), and the National Aeronautics and Space Administration (NASA).

GENERAL PHYSICS

The general physics area contains 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. Research topics in this area include the following:

Professor Shaoul Eazikiel and his students have continued detailed studies of the interaction of two laser fields with three-level systems. The results indicate that atom recoil can play an important role in such processes, and are also affected by self-focusing.

Professor John D. Joannopoulos' group has continued theoretical studies of semiconductor surfaces and defects. Among the topics they have investigated during the past year are: a) Fermi level pinning due to vacancies or steps at GaAs surfaces, 2) core excitonic effects at GaAs surfaces, and 3) metal-semiconductor barriers at Al-GaAs surfaces.

Photoluminescence (PL) experiments with steady-state excitation of amorphous SiO₂, conducted by Professor Marc Kastner and his students, are continuing. A preliminary study of the time-evolution of the PL spectrum was completed and served as the basis for a Ph.D. thesis by
Caroline M. Gee. This work showed that it is necessary to make a complete study of the time and temperature dependence of the PL (using a pulsed fluorine laser as the excitation source) over a wider spectral range than previously examined. The optical system has been rearranged to allow the vacuum monochromator to be used to analyze the PL. This change makes possible measurements from 1050 cm to the infrared.

Professor Hermann A. Haus and his graduate students have continued their work on the mode-locking of semiconductor diode lasers. An optical waveguide sampling device has been demonstrated which shows promise for high rate (10 GHz) sampling of optical signals.

Professor Jin Au Kong and his students have continued studies of electromagnetic waves with application to microstrip antenna and microwave integrated-circuit problems, geophysical subsurface probing, microwave remote sensing, and optical-beam diffraction by periodic structures. Microstrip antenna and microwave integrated-circuit problems have been carried out with rigorous analytical approaches. Seventeen journal articles and 18 symposium articles have been published in the past year.

Professor David Pritchard and his students have demonstrated fundamental new phenomena in the collisional broadening of atomic spectral lines. Line broadening presents a severe challenge to atomic physics because the radiative and collisional interactions occur simultaneously and must be treated together. Professor Pritchard's work uses a single frequency dye laser, instead of spectrometers, and consequently has orders of magnitude, more frequency resolution and sensitivity than conventional studies. The group has observed a deviation from the Lorentzian shape, which has a dispersion shape of roughly the magnitude predicted by recent theories. They have extended and improved these theories with the result that the discrepancy between their experiment and straightforward theoretical prediction is now less than 20 percent. Recent measurements of the polarization of the reemitted light, and the rate of inelastic collisions, also yield new insight atom line broadening.

Dr. Philip Rosenkranz, working with Professor David H. Staelin, has developed an efficient new method for interpreting three-dimensional arrays of remote sensing data. Tests with the scanning multichannel microwave radiometer on the Seasat and Nimbus-7 satellites have yielded good maps over ocean of atmospheric humidity, precipitation, surface wind magnitudes, and sea surface temperature.

Professor Staelin and graduate student Bernard Szabo have also adaptively coded half-tone pictures divided into low and high spatial frequency components. The test images range in quality from slightly annoying to excellent when 0.9 - 1.5 bits per pel are employed. The results are encouraging for full motion video-conference services operating with 512 pixels and compressed to 0.4 - 4 Mbps data rates.

Professors Alan H. Barrett, Philip C. Myers, and their graduate students have studied diffuse clouds, reflection nebulae, and the galactic center regions by observing emission from carbon monoxide in its various isotopic forms, and ammonia. The diffuse clouds are generally believed to be the site of low-mass star formation (such as our sun), and reflection nebulae are clear indications of the interaction between newly formed stars and the dust cloud in which they are imbedded. The observations provide evidence that the molecular clouds are composed of many individual "clumps" with sizes of the order of 0.1 parsecs, gas densities of $\approx 10^4$ cm$^{-3}$, and temperatures of $\sim 10 - 30^\circ$K.

Professor Bernard F. Burke and his group are continuing 6 cm radio survey work using the 300-foot telescope of the National Radio Astronomy Observatory at Green Bank. The first study, including a sample of 2,530 sources, has been finished and will be published shortly. The complete survey, covering the entire celestial circle in a strip 23 $^\circ$ wide at the equator, should be completed during the coming year, and will comprise about 8,000-10,000 sources, three-quarters of which have never been catalogued before. The new survey will be useful for a variety of purposes, and should include a number of new kinds of radio-emitting objects.

The interferometric work of Professor Burke has included use of the Very Large Array (VLA) of the National Radio Astronomy Observatory near Socorro, New Mexico, and continued exploitation of Very-Long-Baseline Interferometer (VLBI). One of the most interesting objects studied by both methods has been the twin quasar 0957+561, the first example of a cosmic gravitational lens. The radiation from a single quasar is split into two images by the gravitational field of an intervening
cluster of galaxies. Most of the refraction is caused by the largest galaxy in the cluster, but the combined VLA and VLBI radio data place many restrictions on the lens model. The matter responsible for refraction cannot reside in the stars observed in the principal galaxy and the associated cluster. Rather, there must be a new component of "dark matter," comprising most of the mass of the system, which influences the proportion of the gravitational lens in a critical way. Such dark matter has long been suspected, in galaxies and clusters of galaxies from indirect evidence, but the gravitational lens observations demonstrate its presence in a convincing way.

Professor Daniel Kleppner and his students have extended their studies of the interaction of Rydberg atoms with blackbody radiation. Because of their enormous size, Rydberg atoms couple to the radiation field more strongly than conventional atoms. As a result, the atoms serve as sensitive radiation detectors in the far infrared. The group has observed transfer of population between different levels due to absorption and stimulated emission of blackbody radiation, and has made quantitative measurements of the rate of photoionization by blackbody radiation in the temperature range 30K to 250K. Photoionization by blackbody radiation has never previously been observed in the laboratory. In a related set of experiments, preliminary evidence for the modification of the blackbody radiation rate by the conducting surfaces which enclose the radiation region has been obtained.

In a separate series of experiments with Rydberg atoms, Professor Kleppner's group has extended their study of the structure of atoms in very strong magnetic fields. By a combination of experimental and computational studies they have confirmed and quantified their earlier conjecture of the existence of an unknown approximate symmetry and constant of motion in the problem.

Professor Clifton G. Fonstad and his group have fabricated, and are now testing, guided wave structures in InP-based III-V compounds for application to optical fiber communications systems. Work has also continued on the study of long, multi-segment contact diode lasers. These devices, which are being built as part of a program to develop monolithic mode-locked diode lasers, are useful for studying the effects of non-uniform current excitation on diode laser performance. A model has been developed which successfully describes the experimentally observed performance.

During the past year, Professor Michael Salour and his students have developed the first tunable, optically pumped, bulk semiconductor platelet laser in an external cavity. Tunability of the laser output was demonstrated in both a CW and a mode-locked configuration where ultrashort picosecond optical pulses were generated at a high (100 MHz) repetition rate. The new lasers have the advantage over diode and dye lasers that virtually any direct-bandgap semiconductor can be used, thereby increasing the spectral range available; they also differ from dye lasers in that no jet fluctuations are present, eliminating a strong source of noise. Moreover, they can be operated in vacuum, eliminating atmospheric pressure fluctuations present in dye laser cavities.

In another series of experiments, Professor Salour's group has developed a new method of unidirectional amplification of light. The technique utilizes laser-induced, velocity-dependent light shifts to create a forward-backward asymmetry in the amplified spontaneous emission rate from an excited sodium vapor, switched on by a pulse of laser light. Based on this experiment, Professor Salour's group has developed a new method of light-by-light switching in a unidirectionally amplifying medium.

During the past year, Professor Erich P. Ippen and his students have completed their new picosecond laser laboratory. They are now beginning investigations of ultrafast processes and high speed devices. Professor Ippen and his students plan to develop sub-picosecond dye lasers and semiconductor diode lasers, and to apply these sources to studies of III-V semiconductor materials and nonlinear optical waveguides.

Professor Frederic Morgenthaler has continued his research on localized magnetostatic modes in non-uniformly, magnetized ferrite geometries. Some of this work will be described in an invited paper to be presented at the Third International Conference on Ferrites to be held in Kyoto, Japan.

Professor David Litster and his group have completed experiments on the orientation dynamics of large molecules in gels. This work demonstrates that the viscosity of water within gels is the same as that of the pure liquid -- a point that had been under dispute. In other picosecond experiments, they have studied critical fluctuations in the binary liquid mixture: n-hexane/nitrobenzene. Their results of the temperature dependence of the rotational relaxation rate near the critical point confirm renormalization group calculations.
The Submicrometer Structures Laboratory, under the direction of Professor Henry I. Smith and Principal Research Scientist John Melngailis, has completed its second year of operation. The main projects in the laboratory are development of X-ray lithography techniques below 1,000 Å, fundamental studies of graphoepitaxy, homographoepitaxy of PbTe on PbSnTe, one-dimensional conduction in silicon ridges 300 Å in diameter, X-ray diffractive elements, reactive ion etching, and surface acoustic wave grating devices. Four papers were presented by members of the Submicron Structures Laboratory at the Electron, Ion, and Photon Beam Technology Symposium in Dallas, and were also submitted for publication. The work on the X-ray diffractive elements has attracted wide interest because thick (>0.5 μm) and fine (0.2 to 0.3 μm) period gold transmission gratings make possible high resolution spectroscopy in the soft X-ray to deep UV range of the electromagnetic spectrum (wavelengths of 5 Å to 1,500 Å). This work was also reported at the Topical Conference on Low Energy X-ray Diagnostics, and has formed the basis of an X-ray astronomy proposal submitted jointly with Professor Claude Canizares to NASA. Examples of collaborative projects are the alignment of liquid crystals by square wave gratings of submicron dimensions (submitted for publication in Physical Review), and the observation of electrical signals from living chicken heart cells using unique micron size electrodes.

Professor Robert J. Birgeneau and his collaborators have recently used the Stanford synchrotron X-ray source to perform a high resolution study of the structure and melting of monolayer krypton on graphite. With carefully prepared Union Carbide 24x graphite, a krypton surface monolayer coherence length of 3,000 Å was observed -- a factor of six larger than in any previous measurement of this kind. The improvement -- which could not have been achieved with conventional X-ray sources -- eliminates finite-size effects as a serious issue in such systems and permits study of the statistical mechanics of an effectively infinite, two-dimensional system. The experiments demonstrate conclusively that in the monolayer region the melting transition is second order. This result, and others obtained in the Stanford experiment, give some hint of the new physics that will be uncovered when the MIT/IBM X-ray spectrometer system at Brookhaven becomes operational in late 1981.

PLASMA DYNAMICS

The plasma dynamics program seeks to understand the basic properties of ionized media in 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.

The plasma dynamics research program in RLE is operated in conjunction with MIT's Plasma Fusion Center (PFC). Staff members hold joint appointments, and DOE support for this work is provided by contracts set up under PFC.

In the past, the possibility of realizing fusion reactors that do not produce neutrons and do not employ radioactive fuels had been considered only a remote possibility. The theoretical work on the physics of high temperature plasmas that has been carried out in RLE during the last two years, coupled with the most recent experimental observations of the properties of high density, magnetically confined plasmas, has changed this perspective. Professor Bruno Coppi and his colleagues have demonstrated that experiments capable of testing the nuclear burning conditions of plasmas composed of deuterium and helium-3, whose fusion reactions do not produce neutrons, can be undertaken on the basis of presently available technologies. This work was made possible by their discovery of a new regime of plasma stability (the so-called "second-stability region") and of omissions in previously existing theories.

The work on the physics of high density magnetically confined plasmas has, in fact, been pioneered by RLE scientists with the Alcator project and the theory program associated with it. In 1981, a new record value for the confinement parameter $n_0T_e$, the product of the peak particle density times the energy replacement time, was reached by the Frascati Torus program that Professor Coppi had been requested to set up in 1971-72 as the next successive step to the Alcator experiment.

Professors George Bekefi and Miklos Porkolab are continuing their work on Versator II. In the Versator II RF heating program, significant results have been achieved during the lower-hybrid current drive experiments which have drawn national attention. In particular, it has been shown
that in the vicinity of the lower-hybrid frequency it is possible to enhance the toroidal current by injecting unidirectional lower-hybrid waves via an array of 4- or 6-phased waveguides ("grill"), thus imparting a net toroidal momentum to the plasma. By injecting 30-50 kW of RF power at a frequency of 800 MHz a net current increase of up to 15 kA has been observed, implying an RF generated current of 25-30 kA. Thus, in these experiments most of the toroidal current is due to the RF power rather than the initial ohmic heating current which was about 30 kA before the RF power was applied. These results show that an RF driven steady-state fusion reactor might be possible. However, contrary to present theory the current drive mechanism operates only at relatively low plasma densities \( n_0 < 10^{13} \text{ cm}^{-3} \), whereas a reactor would operate at densities \( n_0 > 10^{14} \text{ cm}^{-3} \). At present, Professor Bekefi's group is studying ways to increase the density limit. In addition, the physical mechanism responsible for the RF current drive is under detailed investigation.

In parallel with the above, studies of electron-cyclotron heating (ECRH) are under way, in collaboration with the Naval Research Laboratories (NRL). Power at a frequency of 35 GHz and 100 kW is injected into the tokamak using the NRL gyrotron as the microwave source. Preliminary results show electron heating with an efficiency in excess of 60 percent. Combined ECRH and lower-hybrid current drive experiments are planned for the near future.

Professor Abraham Bers and his research group have continued their studies of plasma heating, working toward the goal of energy generation by nuclear fusion. Plasmas can be heated with electromagnetic power converted to random kinetic energy of the plasma particles. The group has completed analytical and computational studies of the nonlinear coupling of microwave power from waveguide arrays to a plasma. These studies include analyses of RF driven steady-state currents in a toroidal plasma -- a problem of importance for a continuously operating, tokamak-type reactor which they have addressed in the past. In a lower frequency regime, where plasma heating on current tokamaks has been successful by ion-cyclotron resonance waves, Professor Bers and Dr. Jean Jacquinot of France (Fontenay-aux-Roses) have initiated a series of antenna analyses for heating large toroidal plasma machines of the near future. This analytical and computational work is being carried forward by Dr. Abhay Ram (visiting scientist) and graduate student Leo P. Harten.

Professor Louis D. Smullin, Dr. Robert J. Klinkowstein, Dr. James H. Irby, and graduate students have been studying instabilities in mirror-confined plasmas. These experiments, performed on the Constance II facility, focus on the problem of micro-instabilities. During the past year, the system has been improved by the development of a new hot-cathode plasma gun that generates hotter and denser plasmas than the washer-guns used heretofore. The guide field strength has been increased from 1.8 to 2.8 kG by adding eight coils taken from the Constance I experiment. A laser Thomson scattering apparatus-laser and five channel polychromator has been completed and calibrated, and is now being installed. Theoretical studies are conducted on the following topics: non-adiabatic particle motion in a min-B mirror; ray tracing for microwave power at the electron-cyclotron-resonance frequency; and the excitation of transverse modes in a warm plasma by a density modulated electron beam. Wall effects such as lowering of the plasma electron temperature by secondary electrons are also being studied. Measurements of electron secondary emission from gas-covered metal targets show anomalously high values compared to clean surfaces.

COMMUNICATION SCIENCES AND ENGINEERING

Research in communication sciences and engineering involves 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. There is a combined program of research and training in communications biophysics, neurophysiology, cognitive information processing, and speech communication. Much of this work concerns sensory or perceptual mechanisms. A related program in linguistics seeks to improve our understanding of languages, which form the basis for communication.

Professors Jeffrey H. Shapiro, Robert S. Kennedy, Robert H. Rediker, and their students have been working on a broad class of problems involving the application of system concepts to the physical framework of optical communications. During the past year progress has been made in the following areas: in atmospheric optical communication, a new synthesis of recent propagation
work and communication theory has substantially furthered understanding of the limitations imposed
on such links by inclement weather conditions. In the area of fundamental quantum effects, an
experiment to generate a light beam with better quantum-noise characteristics than a laser has
been initiated in cooperation with Professor Salour. A program has been undertaken in conjunc-
tion with the Opto-Radar Group of Lincoln Laboratory to study, through theory and experiment,
the effects of atmospheric propagation on the performance of coherent laser radars. Finally,
a program has been started to demonstrate the feasibility of coupling low-power semiconductor
lasers in parallel to produce a high-average-power coherent laser system which combines the
reliability of diode lasers with the higher power and monochromaticity required for space communi-
cations.

Professors Alan V. Oppenheim, Arthur B. Baggeroer, James H. McClellan, and Jae S. Lim, with
graduate students, have developed a number of new signal processing techniques, and are applying
them to speech, bloodflow, image, and geophysical data processing. The speech processing work
is directed toward enhancement of degraded speech and the development of algorithms for robust
speech compression in the presence of additive noise. The work on measurement of bloodflow
characteristics involves spectrum analysis of sounds generated by the heart, and the use of an
active ultrasonic measurement system. In the image processing studies, they have developed a
new image restoration system for improving degraded images, and a new set of conditions under
which an image can be restored from its Fourier transform phase or magnitude alone. The geo-
physical data processing work has involved the development of an algorithm to measure the acoustic
reflection coefficient from the ocean bottom. This algorithm, the Hankel transform, has potential
applications to a number of other problems.

Research in the speech communication group, under the direction of Professors Kenneth H. Stevens
and Victor W. Zue, is concerned with fundamental issues regarding mechanisms and models for
speech production and perception, and with practical applications such as automatic speech recog-
nition and speech synthesis by machine. One of their projects is examining the changes that
occur in the properties of speech sounds when words are concatenated at different rates of
speaking. They are also documenting the properties that remain invariant under these conditions.
Studies of the perception of speech sounds and of electrophysiological responses of the auditory
nerve to speechlike sounds are leading to the development of improved models for the peripheral
processing of speech — models that provide insights into human processing of speech and that
also have application in the design of systems for automatic speech recognition.

Professor Jonathan Allen and his co-workers have further extended a new computational model for
human speech perception based on a weighted search over multiple cues. Interactive software
utilizing an array processor coupled to a high-performance work station has been developed to
facilitate this research.

In another area, Professor Allen and his students have developed several computer programs for
custom integrated circuit design. These include logic and area optimizers for logic arrays and
finite-state machines, special architecture for design rule checking, a compiler for distributed
logic and registers, and a novel speech synthesizer.

Professors William F. Schreiber, Donal E. Troxel, and their students are continuing research on
computer-assisted image processing systems for graphic arts applications. Full-page composition
functions have been incorporated into one system, and a second is in 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.

Research by Professor Louis D. Braida and his colleagues (Nathaniel Durlach, research scientist;
H. Steven Colburn, principal scientist; Adrian Houtsma, sponsored research staff; William
Rabinowitz and Charlotte Reed, research associates) is concerned with auditory perception and
speech communication aids for the hearing impaired, the deaf, and the deaf-blind. Work on
auditory perception has focused on intensity perception, pitch perception, spectral shape percep-
tion, and binaural interaction. This work involves extensive psychophysical experimentation on
both normal and impaired listeners, and the construction of quantitative models of the auditory
system. Work on aids has focused on the development of improved signal-processing schemes for
hearing aids and on the tactile communication of speech. The work on aids includes study of
selective amplification, amplitude compression, and frequency lowering. Also, an attempt is being
made to determine the acoustic characteristics of speech that is spoken with exceptional clarity
and the extent to which these characteristics can be achieved with signal processing of "ordinary
speech."
During the past year, the neurophysiology group, under the direction of Professor Jerome Y. Lettvin, has produced the following studies: Together with Professor Robert M. Rose of the Department of Materials Science and Engineering, the group demonstrated that Caisson Disease, from a pressure of four atmospheres, cannot be attributed to microbubbles or to heterogeneous nucleations, but is caused by vapor cavities transiently produced in non-laminar blood flow and with wave fronts of sound such as are produced by crepitation in the joints. Dr. George A. Plotkin, in collaboration with Professor George Wolf, of the Department of Nutrition and Food Science, has produced a new and extremely reliable test for bladder cancer. Dr. Edward R. Gruberg has shown the distribution of cholinesterase from the two different afferents to the tectum, those of the optic nerve and those of the nucleus isthmi, which are separate moieties. In collaboration with Dr. Eric A. Newman and Dr. Peter Hartline of the Eye Research Institute, he has examined the infrared receptors of rattlesnakes and the cells responding to them in the brain. The anatomical results as well as the physiology are now being prepared for publication. Dr. Raymond has applied his method of parsing the state of an axon from the fluctuations of threshold after a spike to specifying the action of such ions as lithium, and such drugs as ouabain. Professor Lettvin has extended a portion of his theory of membrane control to a new model for ion adsorption kinetics to the membrane surface.

JONATHAN ALLEN
INTRODUCTION

With the formal conclusion of the Leadership Campaign in April 1980, an ongoing consideration during the past year was the establishment and evaluation of major funding needs which were not fully met during the Campaign, as well as approved new areas. MIT's current funding needs include general endowment, student aid in all forms (loans, scholarships, and fellowships), and endowed professorships. These are strongly influenced by the emerging priorities of the new administration as well as the anticipated actions of the Federal government. We look forward to an extensive overall review of Institute priorities in the early fall of 1981, and thus the determination of the Institute's most pressing funding needs.

As an important step in this direction, the President and the Provost, after careful consideration by the Institute's Council on Resources, issued to the faculty in March a revised procedure by which the academic priority of a proposed project is established, its potential for gift support evaluated, and the fundraising priority for it set.

Senior staff in Resource Development continue to work closely with the administration to define each priority in terms of actual dollars needed for effective financial planning, including accurate estimates of startup costs and projections of cash flow based on commitments to be received over a period of years.

The above has come about, in part, as a result of emerging and substantial cutbacks in Federal funding, including student aid and research support, and we have every belief that this unfortunate trend will continue. It is clear that the private sector will not -- and cannot -- pick up the entire slack. The result is not only further demands on already strained private funding sources, but requests for support from faculty members facing actual or imminent Federal funding cutoffs, whose dollar requirements and time constraints make locating effective help from the private sector difficult and complex.

A chief concern in the Institute's development program is to maintain the sense of urgency among our volunteers and constituency for continued strong financial support, now that the Leadership Campaign has drawn to a close. We have stressed "the Institute's case" during this first post-Campaign year, and will continue to do so vigorously in the future. MIT's urgent and increasing financial needs to maintain its leadership must be effectively communicated.

Coupled to all of the above is the intense competition for the philanthropic dollar that MIT faces. Many of our peer institutions -- and some 100 other private colleges and universities -- are in or are planning shortly to launch capital campaigns, and MIT must continue to compete effectively in this very high pressure climate. With the excellent support of a superb faculty and the strong participation from the Institute's senior officers and from members of the Corporation, we plan to intensify our efforts in development. Continuing to be vital components in these efforts will be the Corporation Development Committee and its two major volunteer subgroups -- the National Business Committee, chaired by Richard L. Terrell, Class of 1958, and the Leadership Gifts Committee, chaired by John S. Reed, Class of 1961.

Central to all this is a renewed and enlarged commitment to donor relations and effective communication with alumni, friends, foundations, and corporations who have aided MIT so generously in the past and to whom we will continue to look in the future for both philanthropic giving and the quid pro quo relationships of industrial liaison.
An additional and effective means of enlarging the group of "friends of the Institute" is the Sustaining Fellows Program, now in its second full year, under the effective leadership of Breene M. Kerr, Class of 1951, and a member of the MIT Corporation and its Executive Committee.

There have been some changes over the past year in the organization of the Resource Development effort, in order to meet the challenges outlined above. These have included:

1) intensification of donor relations efforts and proposal development and preparation in the Office of Communications;

2) addition of a fourth senior staff member in the Development Office (to allow for more effective communication with the faculty);

3) addition of a senior person for fundraising for health-related activities (which is now a major research effort within the Institute);

4) merging of the Associates Program with the Industrial Liaison Program, effective July 1, 1981 (the culmination of a process begun several years ago which resulted in the two programs offering the same services and using the same sliding fee schedule); and

5) intensified efforts in Planned Giving luncheons organized by D. Hugh Darden and Thomas R. Henneberry, together with the Alumni Fund and particularly Nancy L. Russell. This important aspect of our development effort involves increased interaction with elements of the Alumni Fund's programs, particularly in class reunion gifts, joint sponsorship of meetings with alumni to discuss planned giving, and the exchange of prospect information and actions. This cooperation and coordination are increasing and are valuable to both organizations.

I have been particularly helped in the definition and management of our overall development program by periodic meetings with the senior department heads in the Resource Development organization.

Private Support

Total private support of MIT during the past year was $47.5 million -- a record high for the past several years, even taking inflation into account. This total comprises $42.9 million in gifts, grants, and bequests, and $4.6 million in support through membership in corporate liaison programs (discussed elsewhere in this report). The total compares with $38.1 million in 1980, $37.4 million in 1979, $34.4 million in 1978, and $29.4 million in 1977. While the impact of the MIT Leadership Campaign continues to be a direct factor in this increased level of support, it is particularly encouraging that only approximately 31 percent of the year's cash flow represents payments on Campaign commitments; the balance represents gifts and payments on pledges made since the conclusion of the Campaign in April 1980.

Sources of gifts for fiscal year 1981 were: alumni, $14.8 million; non-alumni friends, $6.1 million; corporations, corporate foundations, and trade associations, $11.6 million; foundations and charitable trusts, $10.2 million; others, $0.2 million. Included in the totals for alumni and friends are gifts of $1.0 million made to the newly formed Maclaurin Pooled Income Fund and the existing William Barton Rogers Pooled Income Fund. The total income of $4.6 million for corporate liaison programs represented a nine percent increase over the total for fiscal year 1980.

Donors designated expendable and endowed funds as follows: unrestricted, $5.7 million; departments, $10.9 million; faculty salaries, $7.9 million; graduate scholarships and fellowships, $2.7 million; undergraduate grants, awards, and loan funds, $1.6 million; building construction funds, $10.1 million; other funds, $4.0 million.

Corporation Development Committee

The members of the Corporation Development Committee have continued to support the fundraising efforts of the Office since the conclusion of the Leadership Campaign by assisting in the identification of prospects, aiding visits and solicitations, and in planning strategies.
The annual meeting of the Committee was held on November 6 with approximately 70 members in attendance. This year's program revolved around the theme, "Tasks for MIT in the 1980s," and included discussions on potential cooperative efforts between industry and MIT for minority programs, as well as current issues in education and research. The luncheon in the Stratton Student Center was highlighted by the presentation of the Marshall B. Dalton Award for exceptional service to MIT to Samuel E. Lunden, Class of 1921. The afternoon session consisted of two panel discussions, the first centered around research on microprocessors in the Department of Electrical Engineering and Computer Science, and the second was an up-to-date look at biotechnology. We wish to thank members of the Committee and members of the faculty for their participation in these discussions.

The members of the Committee, and we at the Institute, were saddened by the deaths of George W. Burgess, Class of 1929; Philip L. Coleman, Class of 1923; Andrew P. Kellogg, Class of 1924; and Ellis C. Littman, Class of 1933. We will miss their participation in Institute activities.

Corporate Leadership Award

Forty-one alumni were selected to receive the Corporate Leadership Award for calendar years 1979 and 1980. Established in 1976, the award is presented to alumni who are top officers in major United States and Canadian corporations. The presentations were made at MIT following the Corporation luncheon in December. We were pleased that 32 recipients were in attendance at the luncheon.

Development Office

The Development Office, under the direction of Dr. Vincent C. DeBaun, serves as the main data bank for the Institute's development activities, and has continued to help identify and evaluate major donors and prospects; recommend funding strategies; coordinate development contacts by senior officers, deans, department heads, faculty members, and Resource Development staff; and respond to numerous queries about potential support from private sources. Particular efforts were made to expand contacts with the MIT faculty.

With the appointments of Carol A. Hubert (November 1980) and Dr. Jack Oldham (to be effective July 1981) as assistant directors, the Development Office intends to increase its direct support of faculty members seeking private sector support for research and program development.

The Office has continued to develop the capabilities of its word processing center and its support of the entire Resource Development organization. Several new management systems were created, including a prospect control system, a monthly summary of private support, and status reports on key Institute funding projects. The planning responsibility for future information processing needs of Resource Development was assigned to G. Rodger Crowe, associate director.

Foundation Support

Staff responsibility for foundations (both private and corporate) continued to be under the direction of Dr. DeBaun in the Development Office, with the assistance of Mr. Crowe and Ms. Hubert. Working with the President, Provost, Vice President Samuel Goldblith and numerous faculty, Dr. DeBaun continued to expand MIT's interaction with, and support from, foundations through numerous visits to key corporate and private foundations and trusts.

Communications

The Office of Communications, directed by Deborah J. Cohen, combines Proposals and Publications and Donor Relations, and completed its first year of operation on June 30, 1981. Of particular note was the consistently high level of cooperative effort among all members of the newly formed organization.

The Office continued to prepare proposals in support of MIT's major fundraising efforts, and began to update and revise a number of publications describing Institute funding needs. The
staff also assisted senior officers, faculty, and others in Resource Development in increasing contacts with donors through special mailings, luncheons and dinners, and visits to MIT. A plan was developed to expand these efforts further in the coming year.

A major activity at year's end was the planning and execution of the very successful ground-breaking ceremony for the new EG&G Education Center for the Department of Electrical Engineering and Computer Science.

**Planned Giving**

The year was marked by greatly intensified efforts to generate major gifts from individuals out of capital assets. There were many opportunities to assist the efforts of senior officers and to interact effectively with the Resource Development staff, especially Donald P. Severance (director of Leadership Gifts), District Officers, and the MIT Alumni Association and Alumni Fund staffs, especially Ms. Russell (associate director of the Alumni Fund).

Of the $20,942,141 in gifts and bequests from alumni and friends, 37 percent of this -- described as planned gifts -- came through gift arrangements in which Mr. Darden and Mr. Henneberry, director and associate director, respectively, of the Office of Planned Giving and Legal Affairs, provided assistance and guidance.

During the month of October, a pamphlet, "Announcing the Maclaurin Pooled Income Fund," was mailed through Class Estate Secretaries to over 23,000 alumni. A record 13 Planned Giving luncheon meetings were held at various locations in connection with reunion gift efforts.

### Donors Dollars

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<th>Donors</th>
<th>Dollars</th>
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<tr>
<td>Outright gifts generated by Program</td>
<td>$3,167,559</td>
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<tr>
<td>Separately invested unitrusts</td>
<td>624,552*</td>
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<tr>
<td>Gift Annuity</td>
<td>48,781</td>
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<td>William Barton Rogers Pooled Income Fund</td>
<td>880,190</td>
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<tr>
<td>The Maclaurin Pooled Income Fund</td>
<td>2,933,086</td>
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<tr>
<td>Receipts from bequests, testamentary and other trust arrangements</td>
<td>167</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$7,654,169</td>
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* In addition, eight new trusts were established outside MIT and are appropriately reflected in the trust table which follows.

As of June 30, 1981, there were on record with the Institute 1,173 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, 35 estates and outside trusts were closed and fully distributed (amount included in table above). Irrevocable trusts totaled 284 (see table below).

<table>
<thead>
<tr>
<th>Number</th>
<th>Dollars (Current Market Value)</th>
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<tr>
<td>Trusts held by MIT</td>
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<tr>
<td>Trusts held outside MIT</td>
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<tr>
<td>TOTAL</td>
<td>284</td>
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During the year six trust funds held by the Institute totaling $3,901,856 were closed and transferred over free of trust for Institute purposes.

Advice and counsel on a wide variety of legal matters were provided to donors and various members of the Institute's staff and officers of the administration. Proposed changes in the Federal tax law were monitored in regard to income, capital gain, and estate and gift tax law. Some changes, if enacted, would appear to reduce tax incentives for charitable giving. On the other hand, they might provide significant opportunities resulting from increases in disposable income and disposable capital.

During the year, a number of seminars and briefing sessions relating to the tax effects of giving were held for various staff members. Toward the close of the year, a series of seminars was
launched in cooperation with the Leadership Gifts effort to provide briefing on ways of giving for members of the Corporation Development Committee and other volunteer leaders.

Leadership Gifts

During the Leadership Campaign, large gifts resulted for the most part from personal contacts made by the senior officers of the Institute. This will continue to be true. The role of the staff and volunteers of the Leadership Gift group -- in the post-Campaign period as it was during the Campaign -- is to solicit gifts of $2,000 or more as well as to identify and cultivate potentially large donors with the aim of strengthening the base of alumni and friends from whom the Institute may expect major support now and in the years ahead.

This first post-Campaign year has been devoted primarily to the following:

- determining which of the individual prospective donors for the Campaign should continue to be considered prospects;
- pursuing the solicitations started but not completed during the Campaign -- whether by volunteers or by staff;
- broadening our cadre of volunteers by enlisting new top calibre alumni solicitors and identifying new prospects -- especially individuals whose financial circumstances are now believed to justify Leadership Gift solicitation;
- developing a "capital campaign" perception among our Leadership volunteers -- a feeling that they are part of a continuing capital development campaign committed to a new set of vital objectives;
- exposing our volunteers to the less used and more sophisticated means of making gifts, especially for prospects in higher tax brackets or having complicated family financial needs or obligations; and
- helping to identify meaningful contacts for MIT's corporate solicitations.

To these ends, Mr. Severance and three district directors have worked closely with the Leadership Gift committee under the chairmanship of Mr. Reed, Class of 1961; the Alumni Fund and the Alumni Association, especially in coordination with class reunion gift programs and the Alumni Fund's personal solicitation activities; the Office of Planned Giving and Legal Affairs; and the National Business Committee and the Office of Corporate Relations.

The large number of substantial gifts and pledges from individuals this year is in large measure a tribute to hundreds of dedicated volunteers. To them we express our appreciation.

MIT Sustaining Fellows

In its second year, the MIT Sustaining Fellows program continued to recognize, involve, and cultivate alumni and friends whose commitment and support to MIT is particularly exemplary. The Sustaining Fellows membership now numbers over 500, with two-thirds of the participants life members and one-third annual members. For the first time this past year the Sustaining Fellows fund, which is generated by the unrestricted gifts of members to the program, was available for President Paul E. Gray's use; it was allocated toward the renewal of equipment in undergraduate teaching laboratories in the schools of Science and Engineering. The Sustaining Fellows fund totaled $152,000 and constituted 26 percent of the total grants awarded for this purpose.

As part of the ongoing effort to more closely involve Sustaining Fellows with MIT, members continued to be invited as special guests to attend Industrial Liaison Program symposia. Two MIT concerts and the Hayden Gallery exhibition rooms were also featured for Boston area members.

During Dr. Gray's first year as President of MIT, Sustaining Fellows were given the opportunity to become better acquainted with him through regional luncheons and a dinner. These included a luncheon held in Dallas hosted by Edward Vetter; one in Los Angeles hosted by DuWayne Peterson; a dinner in Cambridge; a luncheon in Stamford hosted by Dayton Clewell; two luncheons
in New York hosted by S. James Spitz, Jr., Carl Mueller, and Thomas Creamer; and a luncheon in Cleveland hosted by Joseph Keithley. All these were very successful, thanks to the efforts of the Sustaining Fellows who hosted them. Three more luncheons with Dr. Gray are planned for the fall of 1981. Plans are now under way for an annual event to be held in the fall of 1981 in Cambridge.

Corporation member Breene M. Kerr, Class of 1951, continued to serve as chairman of the MIT Sustaining Fellows, with Professor Elias P. Gyftopoulos serving as faculty chairman. Dr. Jerome B. Wiesner stepped down as honorary chairman of the program upon his retirement as President of MIT, but he will continue to serve on the 27-member Sponsoring Committee. The Chairman of the Corporation and the President of MIT serve as honorary chairmen.

National Business Committee

The National Business Committee (NBC) was restructured during the past year to revitalize it for the post-Leadership Campaign period. Mr. Terrell, Class of 1958, continued to provide excellent leadership as chairman. The new committee of 38 includes 15 continuing prior members and 23 others who have excellent qualifications, most of whom served the NBC during the Leadership Campaign in an unofficial capacity as "NBC associates."

The NBC effort was staffed by Robert Hagopian, Director of Corporate Relations, and Jacquelyn M. Findlay, Assistant Director of Corporate Relations. This effort often involved several additional Resource Development staff members, and their assistance is most appreciated.

NBC members and associates made contacts which resulted in 33 visits to corporations and nine visits of corporate representatives to MIT. They have accepted responsibility for arranging visits with an additional 130 companies.

For the coming year, a new and enlarged list of solicitation prospects has been prepared. It is expected that this newly revised list of prospects will be used during 1981-82, and will permit a substantial increase in the number of companies to be approached by the NBC.

A prime advantage of the NBC, through the active participation of its members, most of whom are important members of the corporate community, has been the establishment of many more relationships with corporations with which MIT has had no, or very limited, contact in the past. This not only has yielded benefits in terms of memberships in the liaison programs, but also in fellowship and research support.

Industrial Liaison

Industrial Liaison activities, directed by Professor James D. Bruce, continued their upward growth during the past year. The Industrial Liaison Program (ILP) and the Associates Program (AP) membership total 208 and 69 member organizations, respectively, with ILP income at $4,094,835 and AP income at $512,125, yielding a combined revenue of $4,606,960. This represents an increase of nine percent from the $4,216,115 total for 1980. These figures represent two records: the ILP crossed the $4 million mark and the AP crossed the $0.5 million mark.

During 1980-81 a total of 27 organizations joined the ILP and 13 companies terminated their memberships. The number of ILP companies in Europe totals 42, and in Japan the total is 29. The AP added 19 new companies during this period and four terminated their memberships.

Interaction of member company personnel with MIT's faculty and staff is the most important service offered by the liaison programs. These interactions continued to increase during this past year with more than 4,000 visits to faculty and staff. In addition, over 400 faculty and staff visits and 400 liaison officer visits to member company locations took place.

Activity in the Office of Publications saw a 40 percent increase, bringing to 14,000 the number of requests for faculty preprints and research reports, with approximately 60,000 individual documents mailed to fill these requests. The Office produced the 1981 Directory of Current Research, utilizing the School of Engineering's Joint Computer Facility. This resulted in this year's Directory being produced in less time with 19 percent more projects listed, and is now immediately
available to be one of the databases of the ILP’s new computer system, described later in this section. In addition, this Office also published the proceedings of "The Decades Ahead: An MIT Perspective, a Symposium for Senior Executives," a major meeting held in Cambridge by the liaison programs in June 1980 and attended by 300 corporate leaders.

Seventeen symposia were presented in the US for ILP member companies by MIT faculty members during the past academic year. These symposia had a total attendance of 2,763, a 58 percent increase in the number of attendees over the past year. In addition, 10 seminars were presented in Japan for ILP Japanese member companies, with a total attendance of 295. A three-day special course was also given in Japan with an attendance of 70. Although such special courses have been presented in Europe for the past five years, this was the first such presentation in Japan.

As part of the ILP’s European program, four intensive short courses were presented during the year, with a total attendance of 153. In addition, three symposia were held in Europe, with a total attendance of 98.

Because of demand from ILP member companies, an intensive short course, "VLSI Design," was given at MIT on July 28 through August 8, 1980. A reorganized version of this short course, "VLSI Design Intensive Laboratory," was given again during the period June 15 through 26, 1981. Combined attendance at the 1980 and 1981 courses was 100.

A major symposium for senior business executives is being planned for London on November 12 and 13, 1981, to be led by President Gray. It will focus on the innovative process as illustrated by the fields of microprocessors and biotechnology.

On April 1, the ILP Office of Information Systems was established under the management of Clyde E. Kelley, formerly assistant director in the AP. This signified the beginning of the process of implementing a computer-based office support system providing functionality in database management, text processing and formatting, spelling verification, electronic mail and file handling, and numerical data processing. Hardware for the system is based on a Digital Equipment Corporation VAX 11/780 minicomputer with 3.5 megabytes of random access memory. During the next year, implementation and customization will take place.

At year’s end, and after extended consideration, the decision was made to merge the AP with the ILP with both to be called the Industrial Liaison Program on July 1, 1981. The merger is the culmination of a process begun several years ago which has resulted in the two programs offering the same services and using the same sliding fee scale which is based upon the member company’s size and use of technology. Assistant directors of the AP will be titled industrial liaison officers, and Cynthia C. Bloomquist, director of the AP, will be appointed assistant director of the ILP.

Sincere thanks to the more than 800 faculty and staff who have participated in the activities of both the ILP and the AP during the past year. Their cooperation is appreciated and vital to the success of industrial liaison at MIT. We are also grateful to the National Business Committee for their help in bringing in new member companies.

Staff Changes

During the year, Barbara G. Stowe, development officer at New England Medical Center, accepted a newly established position as health sciences development officer, reporting to Nelson C. Lees. Beginning August 3, 1981, she will be concerned with promoting financial support for health sciences and technology activities at MIT, including the Whitaker College and the Center for Cancer Research.

In the Development Office, Ms. Hubert was appointed assistant director in November 1980. She came to the Institute from Harvard University, where she was assistant director—foundations. Dr. Oldham was also appointed assistant director of the Development Office and will begin on July 8, 1981. He had previously been director of the Office of Sponsored Programs and Grants Administrator of St. Joseph’s University in Philadelphia.

The Office of Communications was pleased to welcome a new assistant staff writer, Sarah Abrams, in April 1981.
Several changes occurred among Industrial Liaison staff. Mr. Kelley, assistant director of the Associates Program, was promoted to manager of the ILP Office of Information Systems, and Maureen P. Hedden was appointed programmer/analyst. In the Industrial Liaison Program, John T. Preston was promoted to assistant director for marketing, Lucie M. Juneau to staff writer/editor, and Sandra S. Sozanski to conference coordinator-administrative staff. James P. Carpenter and Dr. W. Larry Ritchie were appointed industrial liaison officers, and Harry E. Stephens III, industrial liaison officer, resigned to pursue an M.B.A. degree at Harvard University. In the Associates Program, David R. Lampe and Thomas R. Moebus were appointed assistant directors, and Gary K. Roberts, assistant director, resigned to begin studies toward an S.M. in Management at the Sloan School.

E. Barbara Lewis was appointed executive officer of the MIT Sustaining Fellows, to succeed Eric C. Johnson, who began a two-year leave of absence in January 1981.

Alice W. Tripp will formally retire effective August 1981, after many years at MIT. She has played an important role in the planning and execution of major events at MIT, including the annual Corporation Development Committee meetings in recent years and in the inauguration of President Gray. She will continue to be associated with Resource Development on a consulting basis.

SAMUEL A. GOLDBLITH
During the past year, Lincoln Laboratory has continued in its role as a Federal Contract Research Center for the development of advanced electronics. Agencies of the Department of Defense (DOD) -- the Air Force, Army, Navy, and the Defense Advanced Research Projects Agency -- supplied 87 percent of the Laboratory's budgetary support. The Federal Aviation Administration and the Department of Energy provided most of the non-DOD support. The size of the Laboratory has remained essentially constant. In fiscal year 1981 the operating budget was $149 million, supporting the efforts of 776 professional staff, 75 percent of whom hold advanced degrees. The senior management of the Laboratory has remained unchanged following the several changes of the previous year, except that Paul Rosen has returned from a leave of absence while in government service to become Head of the Engineering Division.

Technical work areas at the Laboratory include radar and optical sensors, measurements, and systems; satellite communications; signal design and processing; lasers; solid-state devices; digital technology; circuitry and data systems; tactical and strategic systems and countermeasures; air traffic control systems; and photovoltaic devices and power systems. Highlights of accomplishments during the past year are summarized below.

**CRUISE MISSILE DETECTION TECHNOLOGY**

The Laboratory has been involved in air defense technology since the inception of the Laboratory in 1951. During the past four years the Laboratory has assisted the United States cruise missile program under a program sponsored by the Defense Advanced Research Projects Agency. The goal of this activity is to help predict survivability of US strategic cruise missiles against the large existing Soviet air defense network and its potential improvements. Air defenses are stressed by the low-altitude flight and low radar-target cross section of the modern cruise missile; and a confident understanding of the air defense limits will require a comprehensive knowledge of radar ground clutter effects, infrared sensor background phenomena, and low-angle radar propagation effects. These technically complex problems are being addressed by a combination of theoretical and experimental efforts. The results of these investigations will be new or improved models of the relevant phenomena, which can be used by DOD agencies to assess survivability of low-flying air vehicles.

The Laboratory's expanding role in this area parallels its role of assisting the ballistic missile offense and defense community with its radar and optics instrumentation at the Kwajalein Missile Range.

**SATELLITE COMMUNICATIONS**

The satellite communications program of the Laboratory has for several years addressed the problem of providing anti-jam communication service at acceptable cost to a large number of mobile and transportable users. To accomplish these objectives, the Laboratory has devised a system concept which incorporates a number of state-of-the-art techniques. This system operates at millimeter wavelengths and employs bandspread modulation for anti-jam characteristics. The Laboratory has designed, built, and demonstrated critical components which have been integrated into a test-bed ground terminal and test-bed satellite payload. The satellite components have been designed taking account of in-orbit considerations such as weight, power, and the radiation environment.
The program described above serves as the major technology base for a new, national extremely high-frequency satellite program. Laboratory personnel have interacted with all of the Services, learning their specific needs and shaping the system design accordingly. The community appears to be converging to a system specification very close to that described above.

MULTIDIMENSIONAL SIGNAL PROCESSING

A basic research program in multidimensional signal processing theory and system analysis is being conducted by the Laboratory. Of particular interest is the application of multidimensional signal theory to the segmentation and classification of photographic imagery on the basis of terrain type and properties. Automatic image segmentation and classification algorithms have potential applications as aids to photointerpretation and as preprocessors or signal conditioners for two-dimensional target detection and recognition systems.

The segmentation algorithm developed at the Laboratory is based on a multiple model approach which was extended to two-dimensional signals for this application. The algorithm begins with a two-dimensional signal model for the various terrain types existing in an image. Estimation theoretic considerations then lead to filtering of the image with a bank of two-dimensional optimal filters, each matched to a particular type of terrain. Error residuals from this bank of filters are used to effect an initial classification of each picture element into one of the defined terrain types, based on a maximum likelihood strategy. An iterative procedure is then used to modify the initial classification assignments in accordance with statistical models of segment size and continuity. The iterative process converges to a segmentation map in which the various region sizes, shapes, and classifications satisfy a maximum a priori probability criterion.

The formulation of this problem in terms of two-dimensional signal modeling and estimation allows one to apply much of the insight that has recently been gained in multidimensional signal processing to an area that has typically only been approached heuristically. In addition, the multiple model formulation is quite general and applicable to a large class of images. Promising results have been obtained in initial applications of the experimental segmentation algorithm to photographs of rural areas.

RESTRUCTURABLE VERY-LARGE-SCALE INTEGRATED CIRCUITS

The Laboratory has been developing a number of techniques for fabricating digital integrated circuits with high levels of integration on a whole wafer scale. A technique has been developed which uses a laser selectively to form connecting vias between two levels of aluminum wiring on a silicon wafer separated by a layer of amorphous silicon. The same laser can be used to remove metal, thus providing a capability of either adding or deleting connections. The ability selectively to make or break high-density connections in fully fabricated devices should allow the achievement of large-area, very-large-scale integrated structures having the redundancy required for high yields using defect avoidance in addition to a significant degree of user customization. Work is in progress to analyze and characterize the connection process in detail and to employ this technique in the fabrication of a restructurable, very-large-scale integration design using complementary metal oxide semiconductor technology.

High levels of complexity in integrated circuits require fine feature resolution and high densities of interconnection. To satisfy these requirements, the Laboratory has developed processes using polyimide as both a high-resolution ion implantation mask and as an insulator. Ion implantation at high currents causes deformation in the conventional photoresist process, but good edge definition is preserved in masking layers of polyimide, which are easily removed after exposure. As an insulating layer in multi-level metal systems, polyimide has significant advantages over silicon dioxide in via definition and insulator integrity. Three levels of metalization separated by polyimide insulation have been demonstrated using these techniques.
Both metal oxide semiconductor circuit density and radiation resistance can be improved by decreasing the gate dielectric thickness. However, the integrity of thermal oxide films becomes inadequate for large-scale integration at thicknesses below 200–300 angstroms. Oxynitride films have been fabricated at the Laboratory by annealing thermal silicon dioxide films in dilute gaseous ammonia. These films are homogeneous and have breakdown field intensities of over 9 millivolts/cm. Unlike films prepared by nitridation of bare surfaces, the thickness of these films is determined by the starting oxide and is largely insensitive to the annealing time. Low radiation flatband shifts are achieved. Conversion of oxide to oxynitride films should make it possible to fabricate, by ordinary processing, reproducible, submicron, radiation-resistant field effect transistors with a gate insulation thickness of 100 angstroms having acceptable breakdown voltages.

MONOLITHIC GALLIUM ARSENIDE INTEGRATED ARRAYS FOR MILLIMETER-WAVE RADAR

An all solid-state, millimeter-wave phased array antenna offers potential advantages for radar ranging and tracking applications, but filling even small apertures with active elements requires large numbers of elements. For many applications millimeter-wave phased arrays become practical only if a significant reduction in the per-element cost is achieved. Monolithic gallium arsenide integrated analog circuits are therefore being developed by the Laboratory. The goal is to develop monolithic components for millimeter-wave phased array applications that achieve savings in weight and space as well as cost.

A promising approach is batch processing of monolithic gallium arsenide integrated circuits, which takes advantage of the low loss characteristics of semi-insulating gallium arsenide substrates for microstrip circuits and the performance available from high-frequency gallium arsenide field-effect transistors and Schottky diodes. A millimeter-wave transceiver combining transmitter, receiver, and phase-shifting functions is the focus of a research program seeking to establish the feasibility of this technology.

A 31-gigahertz monolithic gallium arsenide mixer and preamplifier circuit for the receiver has been fabricated on a gallium arsenide substrate 0.02-cm thick, each unit occupying a 0.50 x 0.25-cm portion of the wafer. The fabricated unit consisted of devices and circuits required for a balanced mixer followed by a low-noise intermediate-frequency amplifier. This monolithic circuit establishes the feasibility of fabricating high-cutoff-frequency Schottky diodes and field effect transistors on the same wafer, which is fundamental to the fabrication of monolithic gallium arsenide heterodyne receivers for millimeter-wave frequencies. The completed units typically exhibit a conversion gain of 4 decibels from the signal frequency of 31 gigahertz to the intermediate frequency of 2 gigahertz. The associated single sideband noise figure was typically 11.5 decibels. A noise figure of 10 decibels is believed to be readily achievable with noise figures ultimately as low as 6 to 7 decibels possible.

The development of monolithic gallium arsenide circuits of increasing complexity is continuing at the Laboratory. A broad range of technology is being pursued including material growth, semiconductor fabrication techniques, circuit analysis and circuit design as well as computer-aided measurement and characterization.

LASER PHOTOCHEMICAL PROCESSING OF MICROSTRUCTURES

Recently, a new class of microfabrication techniques based on laser photochemistry has been conceived and investigated at the Laboratory. An ultraviolet laser beam is focused on a gas-solid interface, where it produces a highly localized heterogeneous reaction by directly severing the bonds of molecules in the gas phase or, in some cases, in an adsorbed layer. Depending on the type of gas, the reaction can produce a metal deposit on a semiconductor surface, cause localized etching, or introduce a dopant into a heated semiconductor by diffusion. In one demonstration, submicrometer-sized metal lines have been written directly on semiconductor surfaces by using a 267-nanometer, frequency-doubled argon ion laser. Localized p-n junctions have been formed by using one laser to control a photochemical reaction while simultaneously heating the surface with a second high-power laser.
By enabling real-time direct writing of microstructures, these processes augment the other microfabrication techniques under development at the Laboratory, which involve multistep lithographic processing. For example, laser photochemical processes could be applied to fault correction or alteration of very-large-scale integration/large-scale integration circuits. Specific applications in photo-mask repair and in the construction of through-wafer vias have already been demonstrated. In addition to application to integrated electronic circuits, laser photochemical processing is also expected to find significant applications in integrated optics and surface-acoustic-wave technology.

AIRCRAFT BEACON-BASED COLLISION AVOIDANCE SYSTEMS

Under sponsorship of the Federal Aviation Administration (FAA), the Laboratory has been developing new radar beacon techniques for ground-based and airborne traffic control applications. This work has led to the development of the discrete address beacon system (DABS), an improved radar beacon system featuring selective addressing and an integral data link. DABS is intended as an evolutionary upgrading of and replacement for the current air traffic control radar beacon system (ATCRBS).

The experience gained with DABS has been applied to the development of an airborne collision avoidance system. This system is called BCAS, for beacon collision avoidance system. It makes use of the radar beacon transponder already carried by most aircraft, thus freeing it from reliance on special equipment on the detected aircraft. BCAS operates by interrogating ATCRBS or DABS transponders in other aircraft and listening to their replies. The range to an aircraft is determined by measuring the two-way transmission delay, and the altitude is determined from the altitude report that is encoded in the transponder reply. Previous attempts to detect and track ATCRBS transponders by interrogations from the air had failed because of severe ground reflections and because all of the transponders in the vicinity of the interrogating aircraft responded to each interrogation, causing overlapping replies. Techniques have been perfected by the Laboratory to overcome these difficulties.

Experimental models of this system were completed by the Laboratory and delivered to the FAA’s Technical Center for operational evaluation last year. A Laboratory experimental unit was installed in a Boeing 727 aircraft and flight tested on cross-country routes and in terminal areas. The equipment is extremely effective in detecting threatening aircraft and providing timely warnings to the pilots. In addition, the equipment has been flown by the Laboratory in live reenactments of the mid-air collision that occurred in San Diego in 1978. These tests have demonstrated that BCAS could have provided ample warning to prevent the San Diego accident.

As part of its implementation process for this system, the FAA has had a commercial avionics manufacturer build preproduction prototypes of the BCAS equipment. The first of these commercial units, built directly from Lincoln Laboratory documentation, was recently delivered to the FAA for evaluation.

WALTER E. MORROW, JR.
Secretary of the Institute and Secretary of the Corporation

The Secretary of the Corporation serves as the Corporation's annually elected Recording Officer and joint signatory with the President in the awarding of the academic degrees of the Institute. The officers and committees of the Corporation rely upon the Secretary of the Institute to provide a range of support for the operation of the Corporation and its committees. This report summarizes the work of the Institute's governing body, under the leadership of Chairman Howard W. Johnson.

Corporation Membership

At the year's end the record total of 99 members of the Corporation included 76 active members, 22 life members emeriti, and one member-elect due to assume office at the October 2, 1981, annual meeting of the Corporation. There were 11 individuals whose membership status changed during 1980-81 in a year of moderate activity for the Membership Committee.

Following the September 26, 1980, annual meeting of the Corporation, Paul E. Gray was inaugurated fourteenth President of the Institute. In the inaugural ceremony, at which Chairman Johnson presided, former Presidents James R. Killian, Jr., Julius A. Stratton, and Jerome B. Wiesner all participated in the installation of Dr. Gray.

That historic event, witnessed by some 6,000 people in Killian Court, was the high point in a three-day period of total immersion in symposia, concerts, exhibitions, and celebrations by the MIT community. The euphoria of months of planning and weeks of execution was capped when the sun shone brightly on that previously rainy and threatening morning, just as President Gray began his inaugural address. The inaugural ceremony was attended by delegates from sister institutions around the globe and by dignitaries from government, industry, and cultural institutions. The extraordinary optimism and enthusiasm of students, faculty, staff, alumni, and members of the Corporation for the popular new President was clearly evidenced by the size and quality of the delegations which participated.

The Corporation, members of the faculty, and the Faculty Council were hosts at the inaugural luncheon in the new MIT Athletics Center immediately following the inaugural ceremony. There were more than 2,700 guests at the luncheon -- the largest single indoor luncheon in the history of the Institute. The excitement of that gathering was heightened by the fact that it was also the first event to be held in the Athletics Center.

President and Mrs. Priscilla Gray were guests of honor. They were joined by their family and the head table guests. Greetings from the delegations, which marched in the academic procession, were brought by representatives from each group. Dr. Johnson expressed appreciation to Professor Kenneth M. Hoffman of the Department of Mathematics for his leadership of the Inaugural Committee and to the countless individuals who had worked so hard to make Dr. Gray's inauguration memorable.

The remainder of the day was given over to receptions for the delegates and the balance of the inaugural guests. In excess of 4,000 guests were received by President and Mrs. Gray at the President's House. The reception utilized the House and its formal garden and the whole of Walker Memorial to accommodate everyone.

It is difficult to do justice to the painstaking work and esprit de corps which punctuated and pervaded the MIT landscape during these proceedings. The outpouring of alumni and faculty sentiment surpassed even the most speculative projections among the inaugural planners. This sentiment, based upon well-earned confidence in Dr. Gray's leadership, brought a sense of Camelot to this campus, along with a profound reaffirmation of MIT's basic purpose. The clouds that have gathered on the basic research horizon since that glorious week in late September 1980,
have become a sober reminder to all of us of the vulnerable nature of our great research universities. We are all the more committed to help President Gray in his efforts to ensure MIT's independence and strength in the period ahead.

At its June 1, 1981, meeting, the Corporation elected to life membership, effective July 1, 1981, Kenneth H. Olsen, Class of 1950, President of Digital Equipment Corporation, who has served two previous, consecutive five-year terms.

At its June meeting, the Corporation further elected the following members to five-year terms, effective July 1, 1981: Harl P. Aldrich, Jr., Class of 1947, President, Haley & Aldrich, Inc.; Elisabeth M. Drake, Class of 1973, Vice President, Arthur D. Little, Inc.; and George M. Keller, Class of 1948, Chairman and Chief Executive Officer, Standard Oil Company of California. Barbara M. Johnston, Class of 1980, Field Engineer, George Hyman Construction Company, was elected a member at the same meeting to a five-year term, effective October 2, 1981.

In addition, Angus N. MacDonald, Class of 1946, President, Angus MacDonald & Company, Inc., who served an earlier five-year term as a member of the Corporation, 1973-78, assumed an ex-officio position on the Corporation by virtue of his election as the 1981-82 president of the Alumni Association. In that position, he succeeds Mr. Aldrich, effective July 1, 1981.

Our life member, George W. Thorn, Chairman, Medical Advisory Board, Howard Hughes Medical Institute, transferred to emeritus status during the year. Dr. Thorn continues as a member of the Whitaker College Visiting Committee and as Vice President of the Whitaker Health Sciences Fund. He has served with distinction as a member of the Corporation since 1965 and as a life member since 1973. Dr. Thorn established a modern record of attendance in excess of 94 percent of the meetings of the Executive Committee during 12 years of continuous service on that Committee, 1969-81. His chairmanship of the Biology Visiting Committee and 25 years of service on visiting committees, 1956-81, and the seminal role he has played in fostering the development of the health sciences and improved health care at the Institute, were recognized by the Corporation at its March meeting.

The Corporation was shocked and saddened by the death of our fellow member, Ellis C. Littmann and his wife, Roslyn, who died in the tragic MGM Grand Hotel fire on November 21, 1980. Mr. and Mrs. Littmann had become mainstays of the Institute and were known and beloved by alumni in the greater St. Louis area, where they lived. Mr. Littmann was elected to the Corporation in 1976 and had served as a member of the Student Affairs, Athletics, and Mechanical Engineering visiting committees, and also as a member of the Corporation Development Committee. Both he and Mrs. Littmann will be sorely missed in Corporation and alumni affairs.

Expiration of term membership has cost the Corporation the formal services of William H. Mills, Class of 1934, President, Mills & Jones Construction Company; James A. Moody, Class of 1975, Attorney-at-Law, Hogan & Hartson, Washington, DC; and Howard L. Richardson, Class of 1931, Consultant and Corporate Director. Mr. Mills was the first individual to be elected to the Corporation from the southeast section of the country. These retiring Corporation members continue their association with the Corporation in many ways as members of various alumni, Corporation, and Institute committees. Effective August 31, 1981, Gregory Anrig will resign as Commissioner of Education of the Commonwealth of Massachusetts to accept a position as President, Educational Testing Service, Inc. of Princeton. His position as an ex-officio member of the Corporation will pass to his successor, who will be named sometime after September 1, 1981.

Under the bylaws of the Boston Museum of Fine Arts (MFA), the President of MIT annually appoints a representative from MIT to serve on the MFA Board of Trustees. During the past year, the Institute's representative has been Professor Phyllis A. Wallace of the Sloan School of Management. Several Corporation members also serve as MFA trustees. Dr. Johnson continued his service as Chairman of the Overseers of the Museum of Fine Arts.

Corporation Joint Advisory Committee on Institute-Wide Affairs

The Corporation Joint Advisory Committee on Institute-Wide Affairs (CJAC) devoted virtually the entire year to a study of CJAC's potential role in the Institute's governance. CJAC met during the year on a monthly schedule to discuss this subject. Several meetings were held with officers of the Institute and of the faculty to develop a consensus about the appropriate focus for this
Secretary of the Institute and Secretary of the Corporation

study. Student and faculty representatives on CJAC have given a monumental number of hours and evenings to the development of a questionnaire survey in support of this effort. Professor Judith Bostock worked tirelessly with student members on this survey and the ensuing report. Their exceptional dedication to the task at hand has been a source of inspiration throughout the year. The writer wishes to acknowledge the leadership of Gregory Smith and the voluntary assistance given to CJAC by Martha L. Bertrand, Senior Associate, Resource Development Office, who served as secretary of CJAC.

Dedications and Special Functions

The Corporation continued to carry prime responsibility for dedications of major facilities and many special functions. Notable ceremonies this year included a dinner on the evening prior to Dr. Gray's inauguration for inaugural guests; the dedication of the George R. Harrison Spectroscopy Laboratory on March 6, 1981; and the groundbreaking ceremony for the EG&G Education Center on June 4 in Huntington Hall and at the site of future construction at the Sherman Fairchild Building.

At the December 5, 1980, meeting of the Corporation, the Corporation adopted the following Resolution on the death of Margaret Hutchinson Compton.

Resolved, That the Corporation of the Massachusetts Institute of Technology expresses its sorrow and deep sense of loss in the death of Margaret Hutchinson Compton, widow of the Institute's ninth President, on Monday, November 17 in Boston. In her passing the Institute family has lost a beloved and cherished former first lady whose warmth, charm and energetic devotion to M.I.T. inspired generations of students, faculty, staff, alumni and friends around the world.

For the past fifty years, she has been a radiating influence in the M.I.T. community and a familiar figure in M.I.T. affairs. The twenty-four years during which Dr. Compton served first as President, 1930-1948, and later as Chairman of the Corporation until 1954, were years of profound change in the Institute's scientific and academic stature. During these years Mrs. Compton became a legend in her own time. The Comptons, through their long and extraordinary partnership, created the legacy of a nobler, happier and friendlier environment for learning at M.I.T. In all of this, Margaret Compton played a guiding role with everyone with whom she came in contact. We join with the members of her family in expressing our enduring appreciation for her life and in mourning their and our great loss.

Later in the afternoon the Corporation held a memorial service for Mrs. Compton in the MIT Chapel; the speakers included Dr. Killian and President Gray.

At the December 5, 1980, Corporation luncheon, our fellow member, Kenneth H. Olsen, President, Digital Equipment Corporation, spoke on "High Technology and Its Implications for MIT in the Future." At the luncheon, the fifth group of Corporation Leadership Award recipients were honored for distinguished corporate leadership by MIT alumni. This group of 41 recipients covered the years 1979 and 1980 and brought the total number of Corporate Leadership awardees to 232 alumni. The Award was first given by the Corporation in 1976.

At the March 6, 1981, Corporation luncheon, Dr. John B. Slaughter, Director of the National Science Foundation, spoke in connection with the dedication of the George Russell Harrison Spectroscopy Laboratory and the Regional Laser Instrumentation Facility, sponsored by the Foundation. Dr. Slaughter spoke about public attitudes towards American science. Mrs. George R. Harrison and members of Dean Harrison's family were present and participated in the afternoon ceremonies.

Corporation Development Committee

The report of the staff organization to support resource development activities of the Institute is included elsewhere in this Report. At the same time no account of trusteeship can be complete without recognizing the participation of members of the Corporation on the Council on Resources of the Institute, the Corporation Development Committee, and the Alumni Fund Board. In
addition, many members of the Corporation have headed or are heading National Sponsoring Committees for particular projects. To illustrate, Edward O. Vetter continued to head a national committee to emphasize the importance of endowed professorships.

Bree M. Kerr continued his role as Chairman of the MIT Sustaining Fellows. Clint W. Murchison, Jr., continued as Chairman of the more than $8 million drive for a new Athletics Center. The Center is scheduled to be ready for dedication in the fall of 1981. Richard L. Terrell continued as Chairman of the National Business Committee seeking major grants from US and foreign corporations. Dr. Wiesner served as the new Chairman of the Council for the Arts at MIT; Mr. Smith continued as Chairman of the Arts Council’s Development Committee; and the Arts and Media Technology Facilities Sponsoring Committee includes a number of Corporation members. In Japan, Yōichi Ayukawa continued to serve as a central figure in organizing support by the Japanese government and Japanese companies. John S. Reed assumed the leadership of a committee in the New York area to encourage private support of MIT. Our Corporation Development Committee member, Samuel E. Lunden, of Los Angeles, received the 1980 Marshall B. Dalton Award of the Corporation Development Committee at its annual meeting "in recognition of conspicuous and sustained service in the enhancing of MIT’s financial independence."

Altogether, these leadership responsibilities and actions by the Corporation represent a renewed sense of institutional purpose. They constitute an unprecedented demonstration by the Institute's governing body of its commitment to secure the necessary resources for MIT's continued independence and strength. The Institute will always be grateful to the above named and to the Corporation as a whole.

This year’s achievement included a record total of more than $45 million in cash gifts, grants, and bequests receipts from the private sector. Notable accomplishments this year were the articulation of new policies governing the establishment of priorities for funding MIT projects and programs from private sources and the procedures for soliciting equipment grants from private companies.

Awards and Prizes

Each year members of the Corporation receive a number of prominent national awards. This year’s tributes to Corporation members included the coveted Perkin Medal to Dr. Ralph Landau on February 13, 1981. The Perkin Medal is conferred jointly by six societies -- the American Chemical Society; the American Institute of Chemical Engineers; the Societe de Chimie Industrielle (American Section); the American Institute of Chemists; the Electrochemical Society; and the Society of Chemical Industry (American Section). Some MIT recipients in the past have been Warren K. Lewis, Robert E. Wilson, and Manson Benedict. The Medal of Honor of the Electronic Industries Association was awarded to William J. Weisz on April 4, 1981. President Gray introduced Mr. Weisz at the Washington, DC, dinner at which Mr. Weisz was being honored.

Meetings

As a matter of record, the Corporation held four meetings during the year. At a time of continued financial stringency, Chairman Johnson, President Gray, and Provost Francis E. Low called upon all segments of the Institute community to continue the budget limitations necessary for planning a future balanced budget. Through its various committees, the Corporation played a key role in communication with student, faculty, alumni, and the general public on the range of questions and issues before MIT.

Special thanks are due once again to the Ad Hoc Committee on Shareholder Responsibility, under the chairmanship of D. Reid Weedon, Jr., and to CJAC, under the chairmanship of Mr. 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 this year as Secretary to the Committee on Shareholder Responsibility -- a year in which the Institute's investments in South Africa continued to be the focal issue.

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 at its March 6, 1981, meeting to approve the establishment of a new S.M. Degree in the Management of Technology. The new degree will be offered under the joint supervision of the faculty of the Sloan School of Management and several departments of the School of Engineering. At the March 6 and June 1 meetings of the Corporation, the establishment of the Whitehead Institute of Biomedical Research as an independent entity adjacent to MIT was discussed at some length.

The year 1980 marked the beginning of Provost Low's participation in the regular meetings of the Corporation. Professor Sheila E. Widnall, Chairman of the Faculty, continued her attendance for a second year. The Corporation expresses appreciation to Professors Low and Widnall who contributed significantly to the discussion in Corporation meetings during the year.

Corporation Visiting Committees

Due to the substantial turnover among deans and department heads, 1980-81 was a year of level activity for the Corporation Visiting Committees. A total of 14 of the 29 committees met during the 1979-80 year. In 1980-81, 14 meetings were also held. The chairmen of the Visiting Committees for the departments of the School of Engineering did not meet in 1980-81 as they did in 1979-80. The expansion of the new Visiting Committee for Whitaker College of Health Sciences, Technology, and Management was continued in 1980-81, through the addition of several professional members.

These 14 meetings in 1980-81 involved roughly one-half of the total Visiting Committee membership, which now exceeds 550 members, with the added appointments to the Whitaker College 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. With the completion of the MIT Leadership Campaign, the Corporation, in response to a request by President Gray, agreed at its March 6, 1981, meeting that a 12- to 18-month cycle for Visiting Committee meetings would be preferable to an 18- to 24-month cycle. Thus, we plan to maintain a level of about 20 meetings a year, evenly divided between the fall and spring semesters. The calendar for 1980-81 was started in this direction, with nine of the Visiting Committees scheduled to meet during the second semester. One was cancelled due to last minute changes in plans. I want to recognize the dedicated work of Mrs. Cara T. Cameron, Administrative Secretary in the Corporation Visiting Committee Office, for the painstaking task of scheduling and staffing these meetings. We are happy to welcome her back to her previous responsibilities.

Several features of the meetings which have proved successful in the past were continued by the Visiting Committees this year. All of the 14 meetings included dinner at which the Committee members were brought together informally with members of the faculty and administration -- and in a few cases with students. Also, the Committees made effective use of private sessions with students on their agenda, further formalizing this additional and valuable means of gaining insight into departmental activities. A number of the Committees for larger Departments included similar separate sessions with junior faculty. Discussions with each of the departments had many common interests, including a systematic follow-up of previous Committee recommendations and reviews of departmental progress in recruitment of minorities and women as students and faculty members.

Attendance by members of the Visiting Committees has been excellent this year. The 14 meetings had an average of 14 members per meeting. In addition, participation in this year's series of meetings by senior officers and deans of the Institute continued at a high level. The presence of these officers at the various meetings enhances the interchange between the committee and the department and often provides welcome catalytic effect which contributes to the success of the meeting. Enduring thanks are due Provost Low for his diligent participation in the meetings, and to the more than 300 faculty members who participated in the sessions of the Visiting Committees.

Of the Committee meetings in the 1979-80 year, all of the chairmen except one have now reported orally to the Corporation, and all have submitted written reports. These reports to the Corporation are important for the successful operation of the Committees, and they provide a broadened forum in which to consider the plans and progress of each department. They are invaluable to the functioning of trusteeship at MIT. The Academic Council systematically receives copies of the written reports when they are approved for distribution by the Executive Committee, and the Council also hears oral reports from the Provost and the responsible dean or vice president as Visiting Committee meetings occur.
We remain handicapped by reduced staffing of the Visiting Committee operation due to budgetary considerations. A six-year search for volunteer assistance with Visiting Committee arrangements has not been successful, although a few volunteers have assisted with arrangements for dinner meetings from time to time. The search for a volunteer continues in order to help fill a staff vacancy. In this interval, the support staff and the writer are sharing the overload.

An interesting development is taking place in the growth of "advisory boards" and committees affiliated with some of the major research laboratories and centers of the Institute. These advisory boards are not formally a part of the Corporation Visiting Committee system. They have been organized by the offices of the Vice President for Research and the Dean of the School of Engineering to serve the needs of specific centers. The advisory bodies will report to the Dean or the Vice President and provide advice to the research program director. A number of Corporation members serve on these advisory boards, and have found them worthwhile and useful for the purposes intended. Advisory boards or committees have now been established for the Energy Laboratory, the Center for Transportation Studies, the Materials Processing Center, the Center for Advanced Engineering Study, and the Plasma Fusion Center. These committees are similar in nature to the Joint Center for Urban Studies Visiting Committee, which has served that Center so well over the years. The Office of the Secretary of the Institute has encouraged and advised the directors of these laboratories in establishing the various advisory boards. There is some potential for confusion between the functions of the advisory boards and the Corporation Visiting Committees, and this aspect of their operation is being studied.

Once again, I wish to thank Dorothy Adler of the MIT 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. At the midpoint of the year, Betsy A. Northrup transferred to the Office of Institute Professor Frank Press. She was succeeded by Iris E. Lazarus in this Office.

There is one individual who heads the list of MIT volunteers without any possible invidious distinction. The magnitude of her contribution is such that each of us responsible for major programs and constituencies of MIT has been aided in the conduct of our official duties by MIT's remarkable Priscilla K. Gray.

We all owe her an enormous debt for the selfless, open-hearted welcome she has given to every program and person at the Institute. It would have been enough justification to recognize what she and President Gray have done in reestablishing the President's House as the residence of the first family after a void of more than a dozen years. That action in itself has made a striking difference in the daily life of MIT. Mrs. Gray's personal interest in human development, as a teacher and homemaker, has inspired students and, indeed, all who have come in contact with her. More than that, however, her boundless energy, optimism, and generous application of her whole self to the welfare of others at MIT has brought to this community a beautiful and exemplary presence among us.

It is appropriate to note in closing that the Corporation has now been chaired for a full decade by Howard W. Johnson. His instinct for organization has brought the individual members of the Corporation into an era of heightened trusteeship, with enlarged opportunities to serve MIT. Working in close harness with the Presidents of the Institute, his leadership of the Institute's governing body has been a major factor in ensuring the continuity of purpose and basic strength of the Institute during these years -- including the weathering of financial vicissitude, the successful conduct of the Institute's largest capital drive in its history, the smooth transition from one presidential administration to another, and the enhancement of quality as the hallmark and capstone of this institution.

VINCENT A. FULMER
Alumni Association

The year 1980-81 marked a continuation of our recent pattern of growth and development. The Alumni Fund broke records in the number of donors, donors over $100, and total dollars contributed. The inauguration of the Institute's 14th President, Paul E. Gray, Class of 1954, drew wide alumni participation with over 1,100 alumni and guests in attendance. Paul and Priscilla Gray graciously extended themselves to visit 17 alumni gatherings, host eight senior dinners, and renew their active knowledge of alumni and alumnae. Special thanks must be extended to Harl P. Aldrich, Jr., Class of 1947, President of the Association, whose support and leadership -- as well as visiting with 19 alumni groups -- throughout the year demonstrated extraordinary commitment to the Association and MIT. A word of thanks goes to Lois Aldrich, his wife, who accompanied Harl whenever possible.

During the past year eight staff members resigned and 12 staff members were hired. James Bidigare, Class of 1978, resigned from his post as Regional Director in New York City to pursue a career in architecture. We were extremely fortunate in attracting Frank Smith, Class of 1968, who has experience in working with alumni associations, to assume this Regional Director position.

As always, the efforts of the Association depend almost wholly on the work of volunteers. Over 5,000 alumni were involved in a multitude of ways. Special note must be made of the work of Christian J. Matthew, Class of 1943, as chairman of the Alumni Fund Board. Chris has led the Fund to new records.

Claude W. Brenner, Class of 1947, took on the task of chairing the Technology Review Advisory Board. Through the efforts of the Board and the Review staff, the Board of Directors approved a substantial investment in an expanded circulation effort for the Review.

Work progressed on the Long-Range Planning Commission chaired by D. Reid Weedon, Jr., Class of 1941. A very successful all-day meeting in Andover generated a wide array of issues. Work continues to progress and we expect specific recommendations to evolve during 1981-82.

ALUMNI RELATIONS

Interest in alumni programs remained at a high level although there were no major programmatic innovations during the year. Much of the interest and enthusiasm was sparked by Dr. Gray's first year as President of the Institute. Nearly 4,500 alumni officers were invited to attend Dr. Gray's Inauguration on Friday, September 26, 1980, which replaced the annual Alumni Officers Conference. More than 1,100 alumni and guests attended the day's events which began with an alumni awards breakfast in Walker Memorial. Dr. Gray, in addition to his visits around the country, opened the Alumni Council on October 27, 1980, before a record audience. He and Priscilla Gray hosted eight senior dinners for 488 students and alumni at their home.

In addition to the dinners, students continued to show an interest in alumni activities and to perceive the Association as a resource. Career-oriented activities offered during Independent Activities Period (IAP) proved to be very popular. The summary of statistics reflects the absence of two student programs this year. The Boston area summer employment program, an experimental program initiated last year, was managed by the Office of Student Employment this past year. The focus was on encouraging students to use that office as a resource, and encouraging local companies to view MIT as a resource. The Survival Seminar Series was not continued because student leadership for this activity did not emerge. As student leaders change, the interest in types of activities change also. This seminar series will probably continue at some point in the future.
The Black Alumni Association of MIT held a national organizational meeting at MIT in October, organized groups in six major cities around the country, and started circulating a newsletter. The Association of MIT Alumnae held six meetings, highlighted by a very successful one-day career seminar in April entitled "Getting On After Getting In," which was attended by 150 women. Technology Day focused on the challenges facing the US automobile industry, attracting large numbers in conjunction with 13 quinquennial reunions.

The National Selection Committee selected the following: nominations for five-year terms on the Corporation -- Dr. Aldrich; George M. Keller, Class of 1948; and Elisabeth Mertz Drake, Class of 1958; as President for one year -- Angus N. MacDonald, Class of 1946; as Vice Presidents for two years -- Joseph G. Gavin, Jr., Class of 1941; and Christian J. Matthew, Class of 1943; as Directors of the Association for two years -- James W. Taylor, Class of 1965; Richard A. Jacobs, Class of 1956; Albert P. Hildebrandt, Class of 1944; Gordon W. Moore, Class of 1960; and Samuel J. Losh, Class of 1954.

The following alumni were elected by national ballot to serve three-year terms on the National Selection Committee: Dr. Drake, District Three; Coralee Stevens Kuhn, Class of 1970, District Five; Frank E. Carroll, Class of 1944, District Six; and Marianna P. Slocum, Class of 1955, District Seven.

The Association supports the Corporation Screening Committee ballot process which elected Barbara M. Johnston, Class of 1980, to serve a five-year term on the Corporation. The Committee on Nominations to the Corporation Visiting Committees recommended to the Corporation that 24 members whose terms had expired be ended, that 37 terms be extended, and that 28 new alumni members be appointed. The Board of Directors appointed 23 new alumni and eight chairman to serve on the eight national boards and committees of the Association.

The Board of Directors approved the following recommendations of the Awards Committee: Bronze Beaver Awards: Theodore T. Miller, Class of 1922; E. Kirkbride Miller, Jr., Class of 1941; Mary Frances Wagley, Class of 1947; and Michael M. Koerner, Class of 1949.

The Harold E. Lobdell, Class of 1917, Distinguished Service Award: Whitworth Ferguson, Class of 1922; Walter J., Class of 1928, and Florence H. Smith (Honorary); Anthony R. Savina, Class of 1930; Eli A. Grossman, Class of 1936; Rutherford Harris, Class of 1937; Louis F. Kreek, Jr., Class of 1948; Bill C. Boozatis, Class of 1960; Paul Rudovsky, Class of 1966; John M. Davis, Class of 1967; and Charles E. Kolb, Jr., Class of 1967.

The George B. Morgan, Class of 1920, Award: Irvine E. Ross, Class of 1930; Walter Godchaux, Jr., Class of 1935; Frederick J. Kolb, Jr., Class of 1938; Bruce Fabens, Class of 1944; David E. Gushee, Class of 1950, and William E. Moss, Class of 1952.

The Presidential Citation was awarded to: the MIT Enterprise Forum Executive Committee; the Alumni of the State of Florida for the 1981 Florida Festival; and the MIT Club of Hong Kong.

Honorary Membership in the Association was awarded to: Joseph J. Martori; Conchita Lobdell Pearson; and James N. Phinney.

Frances H. Bangs was appointed Manager of Class Programs to replace Ann V. Welles. Mr. Martori, Director of Class/Course Programs, was promoted to Associate Secretary and assumed broader responsibilities.
The following statistical summary of events provides a guide to recent trends:

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* Revised figures

REGIONAL ACTIVITIES

For the regional staff who coordinate the alumni relations and annual fund programs of the Association nationwide, this was a year of broadened activities. Traveling to 49 cities -- in some cases, several times, depending upon the size and variety of alumni activities -- we met with some 200 individual alumni officers and attended another 125 or so group meetings or conferences. In the area of the Alumni Fund, the successful Personal Solicitation Program was expanded to include a regional telephone version. Additionally, several life income luncheons were organized regionally to supplement that important Fund program. Turning to alumni relations programs, club activity remained high. A highly successful Florida Festival was held in February, attracting more than 200 alumni and guests from all over that state. We also have witnessed the maturation of two highly successful local programs, the Enterprise Forum and the Boston Seminar Series. We are presently engaged in exporting forms of those programs to alumni groups in other areas which have expressed strong interest.

There is little question that a visit by a member of the MIT community -- faculty or administration -- is a high point of most MIT club calendars. Each year this report singles out for recognition those who, by visiting five or more alumni groups, have made outstanding contributions to alumni activities. This year, those kudos must first be given to President and Mrs. Gray. Paul, frequently accompanied by Priscilla, visited 17 alumni gatherings from Boston to Japan. Also, we appreciate the travels of Dr. Aldrich, President of the Alumni Association, who crisscrossed the continent, meeting with some 19 alumni groups as well. Extraordinary efforts both; we and the alumni are most grateful.

ALUMNI FUND

Under the leadership of Chairman Christian J. Matthew, Class of 1943, the Alumni Fund, marking its 40th anniversary, exceeded the results of all previous years. A total of 24,644 alumni contributed $7,287,000 in gifts to the Institute, representing a five percent increase in the total number of donors to the Fund while the dollar total exceeded last year's record amount by nearly $1 million. These record totals symbolize well the ongoing commitment of the alumni body to support the Institute. Some 1,500 alumni and student volunteers made solicitation visits and calls on behalf of the Alumni Fund -- seeking first-time gifts from individuals who had not contributed before, renewing support from those who had missed making an annual gift the year before, and upgrading gifts from the more than 20,000 alumni whose support of MIT is constant.
During the past year, the Fund expanded its Telethon, Personal Solicitation (PS), Young Alumni, and Major Reunion Gift programs; decreased the volume of direct mail solicitation while increasing the segmentation of mail solicitation; and improved the Matching Gift Program. Further, the Fund implemented a program of donor recognition entitled the "Great Dome Associates."

A total of six telethons was held throughout the year, both on campus and in 15 cities including Toronto, the first non-US telethon site in many years. Approximately 820 callers, of whom roughly half were alumni and half were students, contacted more than 13,000 alumni on a record total of 41 caller nights. With 70 percent of those alumni contacted making pledges, the telethons raised $368,000, meaning that the average solicitor raised about $450 during an evening of telethon calling.

The PS Program was conducted in seven cities during the fall. Two key features of this program are extensive prospect screening and solicitor training. More than 100 solicitors signed on to make personal visits to 450 alumni prospects. Of those visited, 96 percent made a gift and, consistent with the primary objective of the PS Program, nearly two-thirds of them increased their level of giving to MIT.

Support of the Fund among young alumni continues to increase, as evidenced by the record total of 862 alumni in the five most recently graduated classes who made a first-time gift to the Fund. This gives testimony to the effectiveness of both the Young Alumni program, now in its fourth year, and the Senior Gift/Pledge Program. The Class of 1981 presented a gift to MIT in the amount of $14,800, representing contributions in the amount of $2,300 from 229 members of the class which was matched by the Class of 1931, and pledges amounting to $12,500 from 188 seniors.

On Technology Day 1981, the major reunion classes of 1931, 1941, and 1956 reported gifts to MIT totaling $5,110,000. Of this total, the 50th anniversary Class of 1931 gave the largest of the gifts -- $3,137,000. In addition, plans for future gifts from members of the class total $457,000. The Class of 1941, celebrating its 40th anniversary, gave $1,362,000, which included $643,000 toward a Class of 1941 professorship. The gift of the 25th Reunion Class of 1956 was $600,500. Included in the total were gifts and pledges totaling $333,000 to fund a Class of 1956 career development professorship. In the past year, the Major Reunion Gift Program continued to expand with seven additional classes approaching their 25th, 40th, and 50th reunions, having organized committees involving 280 alumni as Gift Committee members. A total of 13 luncheons for alumni approaching 40th and 50th reunions was held in various cities throughout the country. These meetings serve to inform alumni of the variety of means that can be used to make a substantial gift to MIT, including life income plans.

Following several years of discussion, the Alumni Fund Board voted to establish a program entitled the "Great Dome Associates," to recognize alumni who make annual gifts to MIT of $250 or more. In its first year, membership in the "Great Dome Associates" was extended to 1,373 alumni.

Finally, the Alumni Fund underwent a staff reorganization this year. Nancy L. Russell, Associate Director, assumed broadened responsibility for all the Fund's solicitation programs. Brenda L. Hambolton and Mary K. Kyger were promoted to the Assistant Director level; and Roberta A. Carrara was hired as Coordinator of Internal Programs. In summary, the Alumni Fund celebrated its 40th anniversary year in outstanding fashion.

TECHNOLOGY REVIEW

Issues of Technology Review (Volume 83) have been richer and more varied, and we also feel that the articles were more accessible to a wider variety of readers. These improvements were the result of intensified efforts by our editorial and design staffs. We are confident that Volume 83 is an excellent foundation from which to launch a major effort to increase non-alumni "paid" circulation in 1982 and 1983.

There are no singularly notable editorial features to record; rather, the progress of 1980-81 has involved a general enrichment and enlivening of the magazine. There has been more work on the part of editors to make major articles more complete and accessible, and to develop parallel coverage of side issues; more effort by the editors to report timely events; greater success in commissioning articles and shorter comments from leading figures in technology and in areas related to it; and a
more coordinated approach between editors and art directors to achieve effective visual support. "Paid" circulation has increased modestly and now stands at close to 35,000. Despite some weakness in the industry, the Review's advertising volume has remained nearly constant. Our renewal rate of "paid" subscribers hovers between 50 and 60 percent -- acceptable if not stunningly large. The flow of letters from readers continues unabated, and there is strong evidence that the Review is increasingly influential in its field.

The Review's Advisory Board, ably chaired by Mr. Brenner, met twice during the year -- first for a preliminary discussion of a program developed by Peter Gellatly and Evelyn Milardo to utilize new funding in 1981-82 and 1982-83. The intention of this funding is to build the quality and circulation of the magazine so that by 1983-84 its net expense to the Association can be significantly reduced through new income. The second meeting was for a final discussion and approval of these plans. A demographic study of Technology Review readers (both alumni and non-alumni) was completed during the year by Belknap Data Solutions, Ltd., with wholly reassuring results: our readers have essentially identical characteristics (and they are highly acceptable ones in terms of the interests of existing and potential advertisers) and their response to the magazine is very positive. The cost of the survey was covered by funds provided by the Class of 1917. June Kinoshita, who came to us a year ago to be editor of columns and special features, left in June for personal reasons; she was a skillful editor and writer and contributed immensely to our discussions of editorial issues. She will be much missed.

ALUMNI RECORDS AND ADMINISTRATION

The development of the alumni data base management information system continued during the 1980-81 year at a somewhat slower pace than originally planned, due largely to modifications required in the operating environment. The 370/168 resources required by the Adaptable Database System (ADABAS) exceeded the original estimates and at the same time, the expected reduction in Academic/Research usage on the 168 did not materialize. A decision was made to change the hardware configuration, and Information Processing Services personnel were responsible for installing a new IBM 4341 computer for the administrative applications using ADABAS.

Early in calendar 1981 Software AG of North America released a new version of the data base management software which is more compatible with the MIT operating environment. The combined new hardware and software is expected to improve the interactive response which has been a problem for the alumni system in the past. Interactive user query and batch report production from the data base system continued throughout the year and will be converted under CMS in ADABAS version 4 and be integrated into the procedures of the Alumni Association early in July 1981. A special application file was developed for the inauguration of Paul E. Gray as President of the Institute to permit on-line data entry for information related to attendance, hotel accommodations, and participation in various events for the occasion, and the production of various reports for planning and logistical support. Two other major special applications developed during the year are the Solicitation Monitoring System (SMS) for the Alumni Fund and the Technology Review Alumni Circulation Reporting System. A club membership file and history file were also added to the data base in preparation for the full conversion to the new operating environment during the summer of 1981.

A major reorganization of the Records/Administration unit of the Association was developed to staff the operation of the new data base system and provide more effective information management and internal management reporting to support the activities of the Association staff and alumni volunteers on behalf of the Institute.

WILLIAM J. HECHT