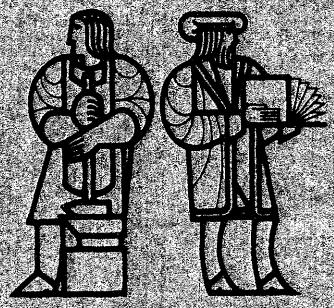
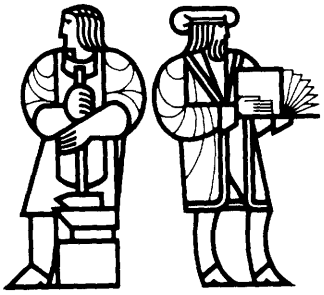


Report of the President

1981-82

Massachusetts Institute of Technology



Report of the President

1981-82

Massachusetts Institute of Technology

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President

The Institute's principal mission is centered on the generation of knowledge, and on its preservation and transmission to new generations of students. During the past year, there has been broad concern about a number of issues which remind us, once again, of the power of knowledge, and of the fact that knowledge is power. The questions of how closely knowledge is held, how freely it is shared, and with whom, have permeated most of the major events and issues of this academic year -- linking together several domains which, at first glance, may not appear to have much in common.

These issues include: first, changing patterns in the organization and support of research; second, questions relating to the international transfer of technology; and third, access to higher education. They illustrate the ways in which the generation, dissemination, and control of knowledge influence the intellectual and organizational development of MIT.

The Generation of Knowledge: Changing Patterns of Research Organization and Support

During the past several years, there has been a steady increase in the scale of industrial support of sponsored research in universities. While, on a relative basis, the scale of such support is still small, it is growing rapidly. At MIT, for example, industrial support of such research has grown from $6.7 million in the 1977-78 academic year to $19.7 million in this past year, and now constitutes about a tenth of the sponsored research conducted on the MIT campus.

For some, the growth in industrial research sponsorship raises almost as many questions as opportunities, and has led to debate within the academic community on how best to ensure the transfer of new ideas and technology from the laboratory to the wider society.

The opportunities generated by industry's increasing support of research are manifold. They include the prospect of stable, long-term funding which may complement government support of basic research, which has declined in real terms in recent years. In addition, and importantly, both universities and industry can benefit from closer communication and ties. After all, both rely, for their own evolution and growth, on the talent and new ideas generated by a vigorous system of higher education. Further, new ideas and technologies which are born in an academic setting must be nurtured and developed before they lead to broad practical uses. This development usually occurs in a business setting, and is aided by effective communication between universities and business. Finally, universities can better chart their own future development in certain areas, such as engineering, if they know about the changing directions and needs in the world of business and industry. This does not mean that universities will forsake their traditional independence and reliance on their faculties to pursue shifting frontiers of knowledge. It does mean, however, that our development can, and should, be informed by these perspectives.

At the same time that we recognize the opportunities and mutual advantages of closer ties between academia and industry, we must consider the questions arising from such association.

The sponsorship of research by business and industry has, at times, created considerable anxiety within universities, and has been the subject of considerable public interest and commentary in the media as well. This is not surprising, because such collaboration carries the possibility of conflict between the essential openness and public accountability of the universities, on the one hand, and the private and proprietary interests of industry on the other. In a context in which knowledge becomes not only power but wealth, questions arise about intellectual property rights, about the closing down of communications between research

colleagues, and about the effect of varying degrees of openness or secrecy on the progress and integrity of research. For some, industrially sponsored research appears to increase the probability that universities will be compromised in their independence and objectivity, or that their priorities and activities will be distorted by private influence.

These kinds of questions led to a gathering last March of people from five major research universities (the California Institute of Technology, Harvard University, MIT, Stanford University, and the University of California) at Pajaro Dunes, California, to explore the issues generated by commercial sponsorship of research and other forms of interaction between industry and academe. The meeting was enhanced by the participation of a number of representatives from industry -- and from the new biotechnology firms in particular. Our purpose was not to generate rules -- we held no charter, indeed no unique interest, which would justify rule making. Rather, it was to try to frame the important questions and to agree, where we could, on some general principles which might be worthy of further consideration by our own institutions and by others not represented at the conference. While the meeting was prompted by issues associated with the commercialization of biotechnology, it was by no means limited to that sphere of activity.

At the end of two days of intensive discussion, we issued a statement to summarize the results. The following excerpts from that statement speak to the principal issues which arise, and the essential conditions which must be satisfied, in the context of industrially sponsored research.

> *. . . It is important that universities and industries maintain basic academic values in their research agreements. Agreements should be constructed, for example, in ways that do not promote a secrecy that will harm the progress of science, impair the education of students, interfere with the choice by faculty members of the scientific questions or lines of inquiry they pursue, or divert the energies of faculty members from their primary obligations to teaching and research.*
>
> *Universities have a responsibility to maintain these values but also to satisfy faculty, students, and the general public that they are being maintained . . . .*
>
> *The traditions of open research and prompt transmission of research results should govern all university research, including research sponsored by industry. Those traditions require that universities encourage open communication about research in progress and research results. However . . . it is appropriate for institutions to file for patent coverage for inventions and discoveries that result from university research. This action may require brief delays in publication or other public disclosure.*
>
> *Receipt of proprietary information from a sponsor may occasionally be desirable to facilitate the research. Such situations must be handled on a case-by-case basis in a manner which neither violates the principles stated above nor interferes with the educational process. Any other restrictions on control of information disclosure by institutions are not appropriate as general policy.*

Experience at MIT and elsewhere suggests that contractual arrangements can be developed which will permit the private sponsorship of research in the university on terms which satisfy both the corporate need for competitive advantage and which preserve the essential openness and independence of the university. I believe that such arrangements, properly constructed, are advantageous to both parties to the agreement and to the larger society and I am hopeful that the scope and frequency of these arrangements will continue to expand.

* * *

The remarkable developments in the life sciences, which have spawned much of the increased interest by industry in sponsoring university research, have influenced the development of new organizations within and between research institutions as well. One such development occurred this past year with our decision to approve an affiliation with MIT of the Whitehead Institute for Biomedical Research, a new not-for-profit research institute in the life sciences. That institute, which has been established by Edwin C. Whitehead, the founder of the Technicon Corporation, a major medical instrumentation company, will focus its research efforts on basic questions in developmental biology.*

The organizational, financial, and intellectual associations between MIT and the Whitehead Institute are complex, and define an entirely new way for institutions to interact and complement each other.

The affiliation of the Whitehead Institute with MIT was first proposed by Dr. David Baltimore, who is the first director of that institution and is the American Cancer Society Professor of Microbiology at MIT. The affiliation reflects his conviction that the quality and effectiveness of research at the nascent Whitehead Institute would be strengthened if a way could be found to involve scientists there in teaching and in the intellectual life of a university. The intermingling of teaching and research, in a way in which each reinforces the other, is the central source of strength of the US research universities. It has long characterized MIT's activities, and it is the underlying motivation for this arrangement with the Whitehead Institute.

The primary relationship between MIT and the Whitehead Institute will be through the appointment, over time, of some 12 to 14 research scientists who will hold joint positions on the MIT faculty and on the senior research staff of the Whitehead Institute. As MIT faculty, they will be selected in accordance with the usual MIT faculty selection processes, and will have all the rights and responsibilities of faculty members at MIT, including supervision of graduate students. Their research facilities and their salaries will be provided by the Whitehead Institute. Graduate student enrollments will expand in proportion, and these additional students will be supported by the Whitehead Institute.

To my mind, the important questions about the Whitehead affiliation have to do with the possible effects it may have on the academic community in the life sciences at MIT. During the year, discussions concerning the proposed affiliation revolved around ways in which such an affiliation could enhance, or disrupt, the intellectual and institutional life of this place. The deliberations of the Corporation about these issues benefited greatly from the debates undertaken by the faculty.

Such a large addition to the life sciences effort at MIT does present certain risks as well as clear opportunities. The principal risk has to do with the fact that as many as one-quarter of the members of the Biology Department faculty will have a dual loyalty, leading to a concern that this dual loyalty could evolve toward a divided allegiance. Will those faculty who have joint appointments function in ways which reflect the values and traditions of their colleagues in the life sciences at MIT? Or will they, acting in response to different interests and divergent forces, comprise an alien block which will come into conflict with the scholarly community which now exists here in the life sciences?

My own view -- which I believe reflects that of a majority of our faculty -- is that the relationships of the joint faculty to MIT are likely to be collegial and congenial, and that their sharing of loyalties with this particular organization will not conflict with, or weaken, the life sciences here. Nor does it seem likely that such relationships will produce activities inappropriate to this academic community. Rather, I believe that the affiliation will enlarge and strengthen teaching and research in the life sciences at MIT and, indeed, will benefit the larger life sciences research community in the Boston area. In brief, we will all gain from the significant expansion in the community of scholars in this field; from the existence

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*Mr. Whitehead has provided a source of assured funding for the operation of the Whitehead Institute; is providing the funds for a new physical facility in the Kendall Square Redevelopment Area adjacent to MIT, the construction of which will begin this fall; and has made a commitment to provide an endowment on the order of $100 million for the long-term support of the Whitehead Institute

of new facilities; a larger community of graduate students, postdoctoral fellows, and faculty; new intellectual resources for instruction, including undergraduate instruction; and expanded opportunities for undergraduate participation in research.

These benefits to MIT would be of considerable importance at any point in the history of this university. They are particularly significant today. For as we develop these expanded opportunities in the life sciences, we can anticipate no growth, and even some reduction, in the traditional forms of support for research and education, not only for those fields but for academic institutions in general.

The MIT-Whitehead relationship represents an exciting organizational innovation. But MIT is not a stranger to inventing new ways to support intellectual and educational objectives. Even a cursory review of our history reveals a myriad of new organizational arrangements: the postwar development of large-scale sponsored research arrangements with the Federal government -- arrangements which raised questions of independence and control of research directions; the establishment and continued operation of the Lincoln Laboratory; the development of interdepartmental research laboratories, beginning with the Research Laboratory of Electronics; the formation and growth of the Industrial Liaison Program; the joint degree programs with the Woods Hole Oceanographic Institution; and a variety of joint programs with Harvard University and with Wellesley College, to cite a few. While the affiliation with the Whitehead Institute is novel, it is, I believe, consonant with our central purposes and with our tradition of responding to new opportunities with new arrangements when that seems desirable.

* * *

Indeed, while I have reported on its development on other occasions, this section of this report would not be complete without mention of the dedication this past spring of yet another new institutional form at MIT -- the Whitaker College of Health Sciences, Technology, and Management, which provides a focus for many of the health-related research and teaching programs of the Institute, including such emerging fields as biomedical engineering and biological physics. Because the teaching and research programs brought together and advanced by this new institutional structure far transcend the concerns of any single department or School at MIT, the term *College* was used for the first time in the history of the Institute.

Through Whitaker College, MIT is now able to extend the opportunities available to, and provide a focus for, faculty members and students throughout the Institute who wish to participate in health-related education and research. Thus the College's educational program provides for the integration of teaching and clinical programs which involve faculty and students from many areas of specialization and which address major human health and medical problems. This involves joining the efforts of physicians, biologists, physical scientists, engineers, psychologists, management experts, and others.

The College incorporates, in addition, the MIT components of the Harvard-MIT Division of Health Sciences and Technology. One of the several collaborative programs with Harvard mentioned earlier, the Division is part of a continuing joint venture of Harvard and MIT to apply the complementary strengths of both universities to the development of new kinds of physicians and other health professionals and to the application of modern science and technology to health and medical problems. The Whitaker College exemplifies superbly the freedom with which educational institutions have always invented new institutional arrangements -- in this case, one that provides an especially rich environment for the advancement of the whole domain of biotechnology.

The creation at MIT of Whitaker College, both as an organization and as a splendid new facility, reflects the creative philanthropy of Mrs. Helen F. Whitaker, Life Member Emerita of the MIT Corporation, and her late husband, U.A. Whitaker. Their interest in the life sciences, in the application of science and engineering to health care and to living systems, and in education in health-related fields, has enabled the Institute to make great progress in these important areas.

Dissemination and Control of Knowledge

Over a period of years, we have seen concerns develop within the Federal administration about the dissemination outside the US of the results of research developments achieved in this country. These concerns derive partially from a conviction that the Soviet Union has become very effective in sifting the US scientific and technical endeavor to obtain and employ information to the military and strategic advantage of the USSR. The concerns derive, too, from the increasing competition in world markets for high-technology products -- a competition exemplified by both Japan and nations in Western Europe.

As a consequence, the concept of export control regulations has been extended beyond materials and devices to include the international traffic in ideas. In this, the international arena, the Federal government clearly recognizes the power of knowledge and the fact that the nation's economic health and stature in international affairs depend greatly on our technological and scientific leadership. There is, I believe, far less understanding of the degree to which quality and continued progress in these areas depend on openness and on sharing of information within the research community, and of the role of open communication and access to research developments in the educational enterprise.

Throughout the year, there has been much discussion of the issues and problems relating to "technology transfer" -- discussion within MIT, within the broader research and academic communities, within government, and among all these constituencies. As this report goes to press, some of these deliberations are reaching conclusion. My remarks here are not intended to forecast these conclusions nor to circumscribe full discussion of these issues at MIT but, rather, to contribute to that discussion some comments of my own on the nature of academic research.

To begin, the research universities in this country are international communities of students, faculty, and research staff who are selected on the basis of ability and promise -- a basis which gives little regard to national origin. Within the universities, research proceeds in an open environment where the exchange of information and ideas is a communal activity, engaged in by all. In fact, the copious informal communication among researchers -- be they faculty members, students, or staff -- is probably more important than the formal communication that accompanies publication at the end of the process. The journals become the journals of record, but the important communication about ongoing work occurs in myriads of conversations -- at meetings, in the laboratory and at lunch, over the telephone, via the computer terminal, and in all the other ways the best people in any field of research are in touch with each other, ways that never enter the formal system of reviewed publication for the record. The whole research process depends very heavily on feedback and on error correction through this wide, informal exposure of results to peers.

Sissela Bok published a paper last winter in the journal *Science, Technology and Human Values* called "Secrecy and Openness in Science: Ethical Considerations." In it, she spoke most tellingly to the connections among openness, integrity, and quality in research:

> *The felt need to take a stand against secrecy also springs from concern for what is most central to the scientific enterprise itself: from a recognition of the damage that secrecy can do to thinking, to creativity, and thus to every form of scientific inquiry. Because secrecy limits feedback and restricts the flow of knowledge, it hampers the scientists' capacity to correct estimates according to new information, to see connections, to take unexpected leaps of thought. And secrecy is expensive in that it fosters needless duplication of efforts, postpones the discovery of errors, and leaves the mediocre without criticism and peer review. Secrecy, therefore, can cut into the quality of research and slow scientific momentum.*

Any proposals to classify sensitive research projects, or to restrict either publication or the nationality of researchers for certain projects, must be carefully weighed against resulting cost to the research process, to its progress, and to its quality. This country's scientific and technological leadership has its roots in the universities, whose strengths are based on open and shared exploration of ideas in education and research. A departure from this principle in certain fields would mean that many institutions would be unwilling to work in those areas, leading to a loss of effort and, most critically, a loss of trained young people in just those fields the government is trying to safeguard.

Certain of these fields are also closely coupled to educational issues. Take the area of very large-scale integrated electronic systems as an example -- one in which the Institute is presently moving toward a major new program and facility. The future of education in electrical engineering and computer science is entirely bound up with the whole issue of integrated systems. In the future, these systems will be the hardware in which electrical engineering and computer design is done, and will form the basis for the curriculum. If universities are constrained from doing research in that area because of restrictions associated with export control, then inevitably the quality of our education in those areas will suffer as well. In the long run, this will do great damage, not only to the universities, but also to the society which depends on them for high quality educational programs in that area.

Keys to Knowledge: Access to Universities and Higher Education

We have long held that universities have an obligation to educate the brightest and most promising students in the society, in order to tap and to nurture the full range of talent for the benefit of all. As long as the powers of knowledge, and particularly opportunities in science and engineering, are closed to individuals in certain segments of the population, our universities are not fulfilling their mission and the society is less than whole. Particularly troublesome this year has been the shift in student financial aid policies and the funding cuts proposed by the Federal administration and their probable impacts on equality of educational opportunity in our country. Beyond financial concerns, there are other factors affecting students' access to and progress in academic institutions -- problems which we must address at MIT.

The Federal posture with respect to financial aid for students has undertaken a discontinuous change in the past two years. Following a quarter century of increased Federal financial aid for students, there has occurred a sharp change in the other direction. In the 1982 Federal budget, the administration proposed and the Congress enacted, a number of serious changes which reduced funding for student aid programs.

This year, the administration recommended further cuts for the years ahead. The proposals for fiscal year 1983 included very large reductions in the funding and eligibility for the major grants and loan programs, including a proposal to eliminate all Federally guaranteed loans to graduate students. While the Congress did moderate the impact of these proposals, severe reductions in the funding of student aid programs remain in place as features of the administration's budget proposals for 1984 and 1985.

What do these signals portend for the state of higher education? We could find ourselves with a system of higher education in which most students have little choice in schools, a system in which the highly selective, private universities are out of the reach of all but a very few. In such a system, the quality of private, undergraduate colleges would inevitably decline as the force of economics pulls many well qualified students away, and many privately supported colleges would face crushing economic pressures as enrollments decline.

If this trend is not stopped, many bright, low-income high school students will lower their eyes from distant and promising horizons. Many college students will become discouraged from going on to graduate school, and many who are now in the midst of their studies -- graduate and undergraduate -- will drop out for financial reasons. Enrollments will shift toward those who can pay their own way. And inevitably, social and economic diversity among college and university students will narrow as educational opportunity becomes tied more closely to economic status. In the long run, the quality of our educational institutions and of our society will suffer. Indeed, I believe that quality is already endangered.

The impact of this abrupt policy change in Federal support of student aid is compounded by the rate at which the costs of higher education are rising. The MIT tuition for the coming year has been set at $8,700, three times the amount for tuition a decade ago. And while the ratio of tuition to starting salary upon graduation has remained essentially constant over the years, the prospect of investing such a large amount and incurring large debts can be overwhelming to many high school students and their families.

Next year we will expect each needy undergraduate student to meet the first $4,000 of his or her need through self-help -- that is, by some combination of loans and term-time jobs. Given the state of the economy and the Federal posture on student aid, one can well ask whether we are approaching the limit to what we can reasonably expect in terms of self-help.

Even when we ask every needy student to come up with $4,000 before we award grants or scholarships, the call on our general funds to support our scholarship programs keeps growing. Until 1979, we seldom spent $1 million a year from general funds to supplement our endowed resources for scholarships. This year, 1982, we spent $2.6 million. With the 1982-83 tuition and self-help level, we will be spending nearly $4 million in general funds to supplement endowed scholarship resources. That number is increasing very rapidly because, as Federal funds decrease, there are more calls on the Institute's general funds to supplement our aid programs.

These changes raise a number of issues for us to consider, including the questions of who has access to an MIT education and how to maintain the economic viability of the Institute. I believe we must review our financial aid policies and our strategies for meeting those policies. In so doing, we must give particular attention to the question of access for minorities and for applicants who cannot afford the full price of an MIT education.

I would suggest that one particular area of study concerns sources of loan support. Fifty years ago, the Technology Loan Fund was created by alumni of the Institute in the face of a national crisis which had some similar dimensions. It made an enormous difference to MIT in the 1930s, and it seems to be time again to call on the graduates of the Institute to increase the flow of funds to MIT for loans to students in support of their educational programs.

There are other factors affecting access to and progress in MIT's educational program. I think we must face squarely and improve our record for attracting and retaining women and minorities on the faculty. We need to do better -- all of us on the faculty and staff -- in attracting outstanding scholars to the Institute, and in nurturing their professional growth once they are here. One way of doing this would be to invite some outstanding minority or women scholars from outside MIT to serve as ambassadors-at-large, to visit the campus periodically, and to assist us in the identification and recruitment of individuals for faculty openings. The appointment of more minorities and women to the department visiting committees will also hlep to open this faculty to the richness and diversity of talent it deserves. I am pleased that we have made some progress in this latter area during the past year.

Another step was taken at the close of the academic year when the Institute was host for the first national Conference on Issues Facing Black Administrators at Predominantly White Colleges and Universities. This conference, which brought together more than 500 persons from colleges and universities all over the country, provided a forum for exploration and discussion of the issues which face minority staff members in those institutions where they were an invisible (or absent) minority until a decade ago. The conference was planned and implemented by the Association of Black Administrators at MIT, under the leadership of Dr. John B. Turner, Associate Dean of the Graduate School, and Dr. Clarence G. Williams, Special Assistant to the President. This conference was enthusiastically received and clearly met a strong need, and it helped to identify a practical agenda for the future.

The keys to knowledge are of transcendent importance to this society, and they must be accessible to all of us. The struggle to make equal opportunity an American reality -- not just an American dream -- is even more important in these times, for the Institute as well as for the society of which we are a part.

UNDERGRADUATE EDUCATION

In this report a year ago I described an intensive and wide-ranging review of issues affecting undergraduate education at MIT -- a review undertaken by the Committee on Educational Policy under the leadership of the then-Chairman of the Faculty, Professor Sheila E. Widnall. That review has continued under Professor Felix M. Villars, present Faculty Chairman. Some comments on progress made during the year are in order.

During the year the CEP recommended, and following extended discussion, the faculty adopted a General Institute Requirement in Writing. This action reflects a widely shared conviction that many MIT students do not write well enough, either for their studies at MIT or for their professional careers later on; that the curriculum as a whole should value and foster good writing; and that the Institute and its students would benefit from greater attention to this problem. The success of this requirement will depend on the acceptance of a shared, curriculum-wide responsibility to emphasize the importance of writing in all subject areas and to provide opportunities for students to develop their writing skills.

The CEP reviews of the Science Requirements and of the Requirement in the Humanities, Arts and Social Sciences continue. These reviews have raised several fundamental questions: What are the primary purposes of the Institute science requirements, and what role do they play for students whose majors are not in science or engineering? How do these requirements affect the diversity of the undergraduate student body? Should there be additions to the core science requirements? How would such additions affect an individual's academic explorations, the pace of MIT, and existing departmental programs? What are the fundamental objectives of the Humanities, Arts, and Social Science requirement within the MIT educational experience? How can this requirement be structured to reflect both appropriate balance among these elements, and reasonable parity with the science requirements?

These and other questions concerning the quality, pace, and pressure of education at MIT are under continued study by the CEP, which expects to make recommendations to the faculty concerning the General Institute Requirements during the coming year.

INSTITUTE FINANCES AND PLANNING

Following five years of precarious balance in the financial operations of the Institute, the budget slipped into deficit in 1981-82. Specifically, we recorded a deficit of $2 million on total operating expenses of $515 million. While the deficit may be small as a fraction of the budget, it is significant and troublesome because it requires the expenditure of capital -- of unrestricted funds functioning as endowment. Thus, future earnings are lost forever, and future budgets are made a bit more difficult to balance.

In an operation as large and as complex as the Institute, it is difficult and somewhat artificial to associate a deficit of this size with any particular causes. Nevertheless, the principal forces causing expenses to grow faster than income seem to be the following:

- The residual impact of several years of double-digit inflation.
- Necessary efforts to achieve more competitive levels of faculty salaries, particularly at the level of assistant professor and primarily in the Schools of Engineering and Management.
- The continued shift of undergraduate interest toward majors in engineering -- now more than two-thirds of all undergraduates who have declared a major are enrolled in the School of Engineering, almost double what it was a decade ago. The increases in enrollment have fallen primarily to Chemical Engineering, Electrical Engineering and Computer Science, and Mechanical Engineering, and have required the allocation of new resources to the School to meet the enrollment pressures -- resources which cannot, in the short run, be offset by budget reductions in areas where enrollments have declined.
- The cost of operating and maintaining new facilities for which endowed maintenance funds fell short of the desired budget.
- Support for important new programs, such as those in plasma fusion and in health sciences and technology.
- Reductions in the portion of indirect costs paid by research sponsors -- reductions caused by the decline of expenditures for research relative to the expenditures for education.

We have now embarked on a review of all programs and activities, with the dual objectives of, first, examining the role and function of each activity and charting its future development in the context of broad, long-range directions for the Institute, and, second, of reducing operating expenses by an amount sufficient both to balance the operating budget and to reduce our reliance on annual unrestricted gifts, grants and bequests, so these precious resources can be used for capital purposes such as building the Institute's endowment. This is a demanding and difficult task, following, as it does, more than a decade of financial stringency. The necessary reduction of expenses and of employment levels will be painful.

I believe that these efforts to reduce and adjust the Institute's operating budget will be most effective and long lasting if they are a part and a consequence of a conscious long-range planning effort -- one which clarifies the mission and points directions for the future development of our manifold activities. Planning in the academic setting is still an immature and developing art. How do we appraise the future potential of complex and diverse activities -- activities which offer no simple measure of effectiveness, impact, or centrality? How do we make informed and rational judgments about resource allocations among these diverse activities?

Planning efforts are now under way in both the academic and support services domains. These efforts will inform budget making for both the 1983-84 and 1984-85 academic years and will help the necessary transition to balanced budgets in future years.

In Special Recognition

From time to time, there are occasions which remind us of the special accomplishments which individuals contribute to the life of an institution. In March, after 15 years as Dean of the School of Science, Robert A. Alberty returned to the ranks of the faculty as Professor of Chemistry. During his tenure as Dean, the School grew both in quality and in the intellectual domains it encompasses. His care for the well-being of the School was demonstrated not only by his attention to research interests and faculty development, but by a deep concern for the quality of the basic undergraduate program, and we are deeply grateful for his contributions to the School and to the Institute as a whole.

Professor Alberty's retirement as fourth Dean of the School coincided with the 50th anniversary of the School of Science, which was established in March 1932 upon the recommendation of then-President Karl T. Compton. Also established formally at that time were the Schools of Engineering and Architecture, as well as the Graduate School, a Division of Humanities, and a Division of Industrial Cooperation. The programs in Engineering and Architecture had been well established, of course, and MIT was generally regarded as a first-rate engineering school. In that context, the establishment of a School of Science represented a milestone in the development of the Institute.

Karl Compton had come to MIT as President in 1930 and soon infused the institution with new ideas and a new spirit, despite the flagging enrollments and economic constraints brought about by the Depression. A noted experimental physicist, Compton had a tremendous influence on the development of basic science at MIT. He foresaw great developments in scientific fields in the future and felt that MIT should be in the vanguard of these advances. Moreover, he believed that if engineering education were to prosper, it would have to be built on a solid foundation in physics, chemistry, and mathematics, and that these fields should be studied in their own right. In order to reach these goals, he set about to develop faculty, promote research, and establish graduate studies.

The School and the Institute have prospered from his vision that the Institute, "to perform its greatest service, must take the lead in actually developing science and its applications as well as in technological instruction." From those early formal beginnings has grown a School of enormous stature, which continues to evolve as its faculty meet and define new intellectual frontiers -- exploring the far reaches of space, the nature of sub-atomic particles, the forces underlying continental shifts, the genetic codes governing life itself. The research endeavors of the eight departments and their associated research centers contribute much to the quality of education at both the undergraduate and graduate levels. And while no longer

the simple "service" departments they were in the days before the School was established, the Departments of Chemistry, Mathematics, and Physics remain at the heart of the academic program for every undergraduate. This insistence on science helps to define an education of extraordinary power, regardless of a student's major field of study, and its spirit infuses the academic enterprise throughout the Institute today.

* * *

The special character of MIT is also seen each year in the achievements and honors of its faculty. While it is not possible to take note of every such distinction, there are some highlights which deserve mention.

The National Academy of Engineering welcomed several more MIT members to its ranks this past year: Professors Peter S. Eagleson of the Department of Civil Engineering, Kent F. Hansen of the Department of Nuclear Engineering, James R. Melcher of the Department of Electrical Engineering and Computer Science, Julian Szekely of the Department of Materials Science and Engineering, and Dr. Bernard Gold of Lincoln Laboratory.

In April, four members of the MIT faculty were elected to the National Academcy of Sciences. They are: Professors Robert W. Balluffi of the Department of Materials Science and Engineering, Robert W. Mann of the Department of Mechanical Engineering, Phillips W. Robbins of the Department of Biology, and Gian-Carlo Rota of the Department of Mathematics. Also during the winter, Institute Professor and former Provost Walter A. Rosenblith was elected Foreign Secretary of the Academy.

The American Academy of Arts and Sciences elected Professor Henry W. Kendall of the Department of Physics and Professor James Wei, Head of the Department of Chemical Engineering, as members during the past year; and elected Professor Herman Feshbach, Head of the Department of Physics, as president of that organization.

Three members of the MIT community were surprise recipients of MacArthur Prizes during this academic year. The MacArthur Prize Fellows Program was established by the John D. and Catherine MacArthur Foundation to recognize and give certain talented individuals the financial freedom to be creative and perhaps to produce works of genius. It places no restraints on how the five-year stipends are to be spent. The MIT recipients were Mr. Michael D. Woodford, a graduate student in the Department of Economics; Dr. Richard Mulligan, a postdoctoral fellow at the Center for Cancer Research and a fellow in Medicine at the Harvard Medical School; and Dr. Raphael C. Lee, a surgeon at the Massachusetts General Hospital and a research scientist in Electrical Engineering at MIT.

Two MIT faculty members were recipients of major international prizes during the past year. In September 1981, Institute Professor, Emeritus, Victor F. Weisskopf was selected as co-recipient (along with Professor Freeman Dyson and Professor Gerard 't Hooft) of the 1981 Wolf Prize in Physics. The Prizes are awarded by the Wolf Foundation "for outstanding contributions on behalf of mankind" in the fields of architecture, mathematics, chemistry, physics, and medicine. Professor Weisskopf and his co-recipients were awarded the Prize for "their outstanding contributions to theoretical physics, especially in the development and application of the quantum theory of fields."

In May 1982, Carroll L. Wilson (Mitsui Professor, Emeritus, in Problems of Contemporary Technology) was awarded the 1982 John and Alice Tyler Ecology/Energy Prize, considered the world's most prestigious prize in the area of energy and the environment. The Prize, awarded by the John and Alice Tyler Foundation, was given in recognition of Professor Wilson's leadership, throughout his career, in the assessment of global energy resources and in the development and management of atomic energy.

In February, Professor Arthur K. Kerman, Director of the Center for Theoretical Physics, and I, were named to the White House Science Council, a group of 13 scientists and engineers who will advise Dr. George A. Keyworth II, Director of the Office of Science and Technology Policy in the Executive Office of the President.

Within the Institute, Herman A. Haus, Elihu Thomson Professor of Electrical Engineering was selected by faculty colleagues to be the 1982-83 recipient of the James R. Killian, Jr. Faculty Achievement Award. The Award recognizes extraordinary professional accomplishments and service to the Institute. The Award citation reads, in part, "Dr. Haus's analytical work goes beyond solving the question of the moment. His talents enable him to bridge the gap between fundamental science and engineering applications -- regularly putting novel engineering concepts on firm, theoretical ground. . . and developing new methodologies to clarify and extend understanding. . . ."

Several changes in the academic administration were announced during this past year. These changes include the selection of John M. Deutch as Dean of the School of Science (succeeding Robert A. Alberty). Dean Deutch took up his new responsibilities on March 1, 1982. New department heads announced during the year include Donald L.M. Blackmer, Department of Political Science (effective January 15, 1982); Gary A. Hack, Department of Urban Studies and Planning (effective August 1, 1982); Merton C. Flemings, Department of Materials Science and Engineering (effective September 1, 1982); Ann F. Friedlaender, Department of Economics (effective January 15, 1983); Joel Moses, Department of Electrical Engineering and Computer Science (effective September 1, 1981); John Myer, Department of Architecture (effective September 1, 1982, succeeding Professor Julian Beinart, who served as interim head during the year); T. Francis Ogilvie, Department of Ocean Engineering (effective February 1, 1982, succeeding Professor Chryssostomos Chryssostomidis, who served as acting head during the year); and Christopher T. Walsh, Department of Chemistry (effective July 1, 1982).

Other changes in the academic administration announced during the year included the appointment of H. James Brown as Director of the Harvard-MIT Joint Center for Urban Studies; Chryssostomos Chryssostomidis as Director of the MIT Sea Grant Program; Thomas H. Lee as Director of the Electric Power Systems Laboratory; Daniel H. Gould as Assistant to the Provost for Administration; Herbert H. Richardson as Associate Dean of the School of Engineering; Alvin J. Silk as Associate Dean of the Sloan School of Management; and Kenneth A. Smith as Vice President for Research (continuing as Associate Provost as well).

Several changes in the Institute's administration also were announced during the year. Among them were the appointment of Patricia Bell Scott as Assistant Equal Opportunity Officer, William R. Dickson as Senior Vice President, Deborah A. Hoover as Executive Director of the MIT Council for the Arts, William D. MacLaurin as Director of the Office of Minority Education (succeeding Clarence G. Williams who had been serving as acting director), William L. Porter as Special Assistant to the President for the Arts, Shirley M. Picardi as Secretary of the Alumni Association, Arthur R. Wagman as Bursar, and Elizabeth J. Whittaker, as Assistant Secretary of the Corporation.

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

Edward J. Hanley, a member of the MIT Corporation for 26 years and of its Executive Committee for 10 years, died in March 1982 at the age of 79. A distinguished leader of the steel industry, he was especially active in the life of the Institute, participating in numerous alumni committees and councils, and serving as president of the Alumni Association in 1959-60.

Charles E. Holt III, Professor of Biology, died in February 1982, at the age of 45. Widely recognized for his contributions as a research scientist, particularly in the genetics and physiology of development, "Ned" Holt's innovative approaches to laboratory teaching led to a reorganization of the entire laboratory instruction program in the Department of Biology.

Roman Jakobson, Institute Professor, Emeritus, known as the founder of modern phonology, died at the age of 85, in July 1982. A widely published author of some 500 books and essays, he was a monumental figure whose influence in linguistics and literary studies spanned nearly 70 years.

Roy Kaplow, who held a joint appointment as Professor in the Department of Materials Science and Engineering and in the Division for Study and Research in Education, died in January 1982 at the age of 49. Long active in faculty governance and service to the Institute, his research interests ranged from the materials field to solar energy to the use of computers for education.

In June 1982, Associate Professor of Meteorology, Emeritus, Delbar P. Keily, died at the age of 74 years. A specialist in the field of aircraft and meteorological instrumentation, he graduated from MIT in 1934 and spent his entire career at MIT, as researcher and then as faculty member until his retirement in 1973.

Paul V. Keyser, an MIT graduate, former MIT Corporation member, and retired executive vice president of the Mobil Oil Corporation, died in February 1982 at the age of 75. Highly regarded for his activities on behalf of the Corporation and its various committees, he was even more widely known for his service in every aspect of alumni affairs, including two consecutive terms as president of the Alumni Association in 1970-72.

Thomas F. Morrow, a class of 1935 alumnus and member of the MIT Corporation from 1963-68, died in June 1982, at the age of 69. A retired group vice president of the Chrysler Corporation, he was active in alumni affairs and was a long-time member of the Corporation Development Committee.

In August 1982, John T.R. Nickerson, Professor of Food Technology, Emeritus, died at the age of 76. A specialist in food preservation, Professor Nickerson received his bachelor's, master's and doctorate degrees from MIT, and was a member of the teaching staff and faculty at the Institute from 1948 until his retirement in 1972.

In July 1982, Norman J. Padelford, Professor of International Relations, Emeritus, died at the age of 78. Instrumental in planning U.S. policy on the establishment of the United Nations, he also served as consultant at the Department of State during World War II.

Thomas P. Pitré, chief administrator of financial aid at MIT for more than 30 years, died in February 1982 at the age of 83. Dean Pitre came to MIT as a faculty member in 1920, and later served in the office of the Dean for Student Affairs, devoting much of his time to counseling students.

Raymond S. Stevens, a graduate of the class of 1919, former member of the MIT Corporation, and former president of Arthur D. Little Company, died in February 1982 at the age of 87. A participant in all the major capital drives of the Institute, he had a distinguished record of service to the Institute as an alumni leader.

Charles A. Thomas, a Life Member, Emeritus, of the MIT Corporation, died in March 1982, at the age of 82. A distinguished scientist and leader of the chemical industry and staunch supporter of MIT, he participated in the affairs of the Corporation, the Alumni Association, and the Institute for over 30 years.

PAUL E. GRAY, President

September 13, 1982

Statistics for the Year

The following paragraphs report briefly on the various aspects of the Institute's activities and operations during 1981-82.

Registration

In 1981-82 student enrollment was 9,510, compared with 9,365 in 1980-81. This total was comprised of 4,562 undergraduates (compared with 4,577 the previous year), and 4,948 graduate students (compared with 4,788 the previous year). Graduate students who entered MIT last year held degrees from 373 colleges and universities, 229 American and 144 foreign. The international student population was 1,956, representing 10 percent of the undergraduate and 30 percent of the graduate population. These students were citizens of 95 countries.

Degrees awarded by the Institute in 1981-82 included 1,128 bachelor's degrees, 1,118 master's degrees, 64 engineer's degrees, 403 doctoral degrees -- a total of 2,713.

The number of women at MIT, both graduate and undergraduate, has continued to increase. In 1981-82, there were 1,879 women students (977 undergraduate and 902 graduate) at the Institute, compared with 1,737 (891 undergraduate and 846 graduate) in 1980-81. In September 1981, 257 first-year women entered MIT, representing 25 percent of the entering class.

In 1981-82, there were 929 minority* students (725 undergraduate and 204 graduate) at the Institute, compared with 779 (611 undergraduate and 168 graduate) in 1980-81. The first-year class entering in September 1981 included 224 minority students, representing 22 percent of the class.

Student Financial Aid

During the academic year 1981-82 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. Loans obtained from commercial sources showed a significant increase.

A total of 2,441 undergraduates who demonstrated the need for assistance (54 percent of the enrollment) received $10,567,518 in grant aid and $2,022,177 in loans. The total, $12,589,695 represents a 22 percent increase in aid compared with last year.

Grant assistance was provided by the scholarship endowment in the amount of $3,299,809; by outside gifts and Federal allocations to MIT for scholarships in the amount of $1,787,163; and by direct grants to needy students totaling $2,697,047 (a 13 percent increase over last year). Scholarship assistance from MIT's own operating funds was provided to the extent of $2,634,822 (an 80 percent increase over last year's level and the largest allocation ever). The special program of scholarship aid to minority group students represented an additional $148,677 from specially designated funds. An additional 402 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 $1,101,339 and which raised the principal of the endowment to $30,512,551.

Loans totaling $2,022,177 were made to needy undergraduates -- an 18 percent decrease from last year. Of this amount, $363,858 came from the Technology Loan Fund and $1,658,319 from the National Direct Loan Fund. Not included in the foregoing summary is an additional $7,386,862 obtained by undergraduates from state-administered Guaranteed Loan Programs and other outside sources. This represents a 36 percent increase in the use of these programs over last year.

Graduate students obtained $694,267 from the Technology Loan Fund, about half of which was loaned to international students and did not qualify for the Federal interest subsidies and guarantees available under the Guaranteed Student Loan Program. In addition, $295,175 was loaned by MIT under the Guaranteed Student Loan Program. The total, $989,442, represents a significant increase over last year's level. Graduate students obtained $4,041,875 from outside sources, under the Guaranteed Student Loan Program -- almost exactly last year's level. The total loaned by MIT to both graduate and undergraduate students was $3,011,619, again about equal to last year's level.

Career Planning and Placement

The employment outlook for students graduating in 1981-82 was as full of contradiction as the economy as a whole. In spite of the recession, the number of employers coming to the Office to recruit was the largest on record -- 450, up from 406 the year before. Nevertheless, a number of students in a number of disciplines were without jobs at graduation. It was a

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

frustrating year for many students in architecture, chemical and civil engineering, geology, political science, and urban studies, but not for all students in these fields. In civil engineering, for example, students in structures generally fared well, while students in water resources fared badly. Students in chemical engineering did well if they interviewed early in the year. The oil industry was hungry for engineers in the fall and helped to bid up salaries sharply. The average offer to bachelor's degree candidates in chemical engineering rose 12 percent over the year before to $27,500; offers to master's candidates rose more than 15 percent, and offers to Ph.D. candidates jumped as much as 23 percent. But the industry reversed its hiring plans during the winter and made a minimum of offers in the spring.

Students responded to the cloudy job market by making active use of the Office. A total of 1,556 students and postdoctorals had 10,004 interviews with visiting employers. The number of interviews is the highest in the history of the Office. Eight hundred and twenty-seven students submitted resumes for the Science and Engineering Resume Book, also a record. The number of alumni using the Office rose to 419 from 356 the year before.

The underlying demand for technical people -- the demand one can expect to see when the economy recovers -- is very strong. Over 550 employers confirmed recruiting dates with the Office at the start of the year.

Finances

As reported by the Vice President for Financial Operations and the Treasurer, the total financial operations of the Institute, including sponsored research, amounted to $515,428,000, an increase of 8.2 percent over 1980-81. Education and general expenses -- excluding the direct expenses of department and interdepartmental research, and the Lincoln Laboratory -- amounted to $227,165,000 during 1981-82, compared to $199,924,000 in 1980-81. The direct expenses of campus departmental and interdepartmental sponsored research increased from $138,345,000 to $143,537,000; the direct expenses of the Lincoln Laboratory's sponsored research increased from $138,068,000 to $144,726,000 because of an overall increase in governmental research support.

For the first time in six years the financial operations of the Institute were not in balance, with expenses exceeding income by approximately $2 million. Current revenues used to meet the Institute's operating expenses totaled $505,941,000, augmented by $7,460,000 in unrestricted funds. The remaining $2,027,000 needed to meet expenses was made up of $975,000 in other fund balances and $1,052,000 in funds functioning as endowment.

The construction program of the Institute continued to make progress in 1981-82 with the book value of educational plant facilities increasing from $262,658,000 to $278,949,000.

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 $463,786,000 and a market value of $539,736,000. This compares to book and market values of $442,112,000 and $579,875,000 last year.

Gifts

Gifts, grants, and bequests to MIT from private donors decreased slightly to a total of $41,055,000 in 1981-82, compared with the record high of $42,934,000 in 1980-81. The 1981-82 figure includes unrestricted direct gifts to the Alumni Fund of $2,700,000 which constituted part of the total $7,715,000 reported by the Alumni Fund in 1981-82.

Physical Plant and Campus Environment

During the year we dedicated the Health Services Center Building, the new home of the Medical Department, and the associated building which is home for the Whitaker College of Health Sciences, Technology, and Management. These splendid new structures, which will be fully completed in fall of 1982, are landmarks at MIT in two respects. First, they represent the most costly construction project ever undertaken at the Institute. Second, they comprise

the first new construction for academic purposes east of Ames Street, and represent the first steps in what will be a decade-long redevelopment of that area to better serve the long-term needs of the Institute.

Other major building projects during the year included the completion and occupancy of the dormitory at 500 Memorial Drive; the opening of 70 Memorial Drive, which provides classrooms and offices for the Program in Science, Technology, and Society and the Sloan School; and the completely renovated classroom and office building at One Amherst Street for the Sloan School and the Energy Laboratory.

Major renovation projects completed during the year were space for the Department of Architecture on the third and fourth floors of the former Epsco Building on the north side of the campus, and the first and basement floors in Building 35 for the Laboratory for Manufacturing and Productivity.

Major projects under construction are the EG&G (Edgerton, Germeshausen & Grier) Education Center, a five story brick building to be connected to the Fairchild Building link and Building 24; the Arts and Media Technology Building on Ames Street next to the Seeley G. Mudd Building; a new 24-bed residence and conference facility adjacent to and in support of Endicott House in Dedham, Mass.; renovations to the basement, first, and third floors of the Sloan Building on Memorial Drive, and to the Plasma Fusion Tandem Mirror Project in the Nabisco Building on Albany Street.

The Dining Program originally proposed by the Committee on Campus Dining completed its second year of operation. The efforts of the House Commons Committees, the Dining Advisory Board, students, and staff have contributed greatly to its success.

Dining-related issues involving the east side of campus received considerable attention this year. Goody, Clancy and Associates, Inc. completed their study of Walker Memorial. This study explored ways to provide dining facilities for the students on the east side of campus, permitting them to have commons dining and to conduct dining-related programs, while still accommodating a large lunchtime clientele from throughout the MIT community. The report presented a number of alternatives and described the difficulty of using this facility for these multiple purposes. The physical placement and size of spaces, the constraints on changes within Morss Hall, and the economics of the project are the major factors which limit reaching the goal.

One of the alternatives mentioned in the report was the installation of kitchens in East Campus and Senior House. Students in these houses have been on a "limited" commons participation until such time as the issue of dining for east campus residents was resolved. Residents of these houses developed a well conceived proposal for placement and operation of kitchens in their respective houses, a proposal which was accepted by the administration, and approved by the Corporation. The student client team and appropriate administrative offices are now beginning the programming and design phases for the new kitchens. The student group responsible for the proposal was honored by being chosen a recipient of one of the William L. Stewart, Jr. Awards.

In conjunction with the Safety Office, a program of smoke detector installation to meet new fire safety codes is under way. Approximately 2,200 smoke detectors are to be installed in all dormitory rooms and all apartments. Currently completed are Eastgate, Westgate, Baker House, and MacGregor House. The balance of the system is to be completed over the next year.

FIGURE 1
FINANCIAL AID TO UNDERGRADUATE STUDENTS FROM ALL SOURCES, 1974-1982

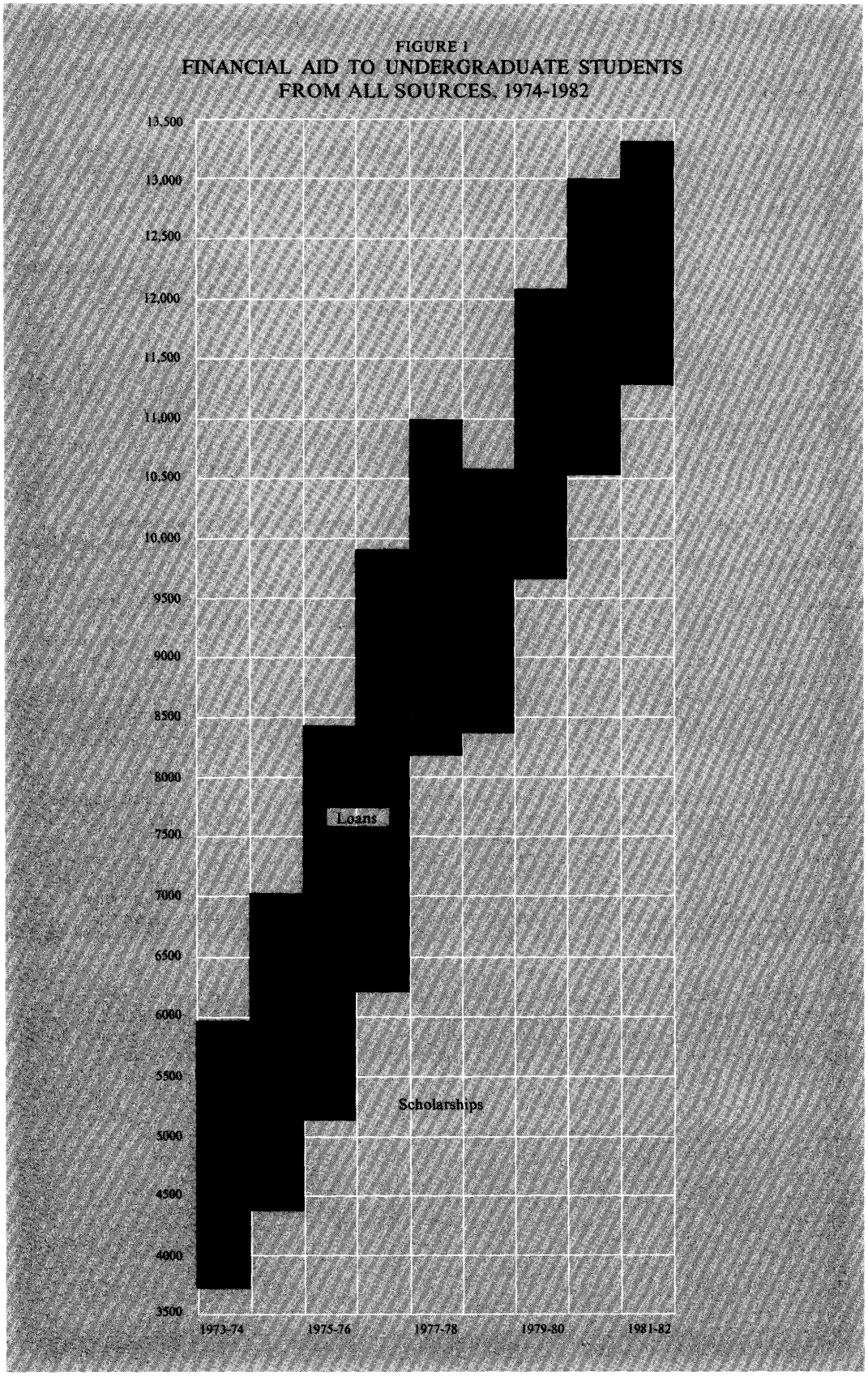


FIGURE 2

FINANCIAL AID TO GRADUATE STUDENTS AWARDED BY MIT 1974-1982

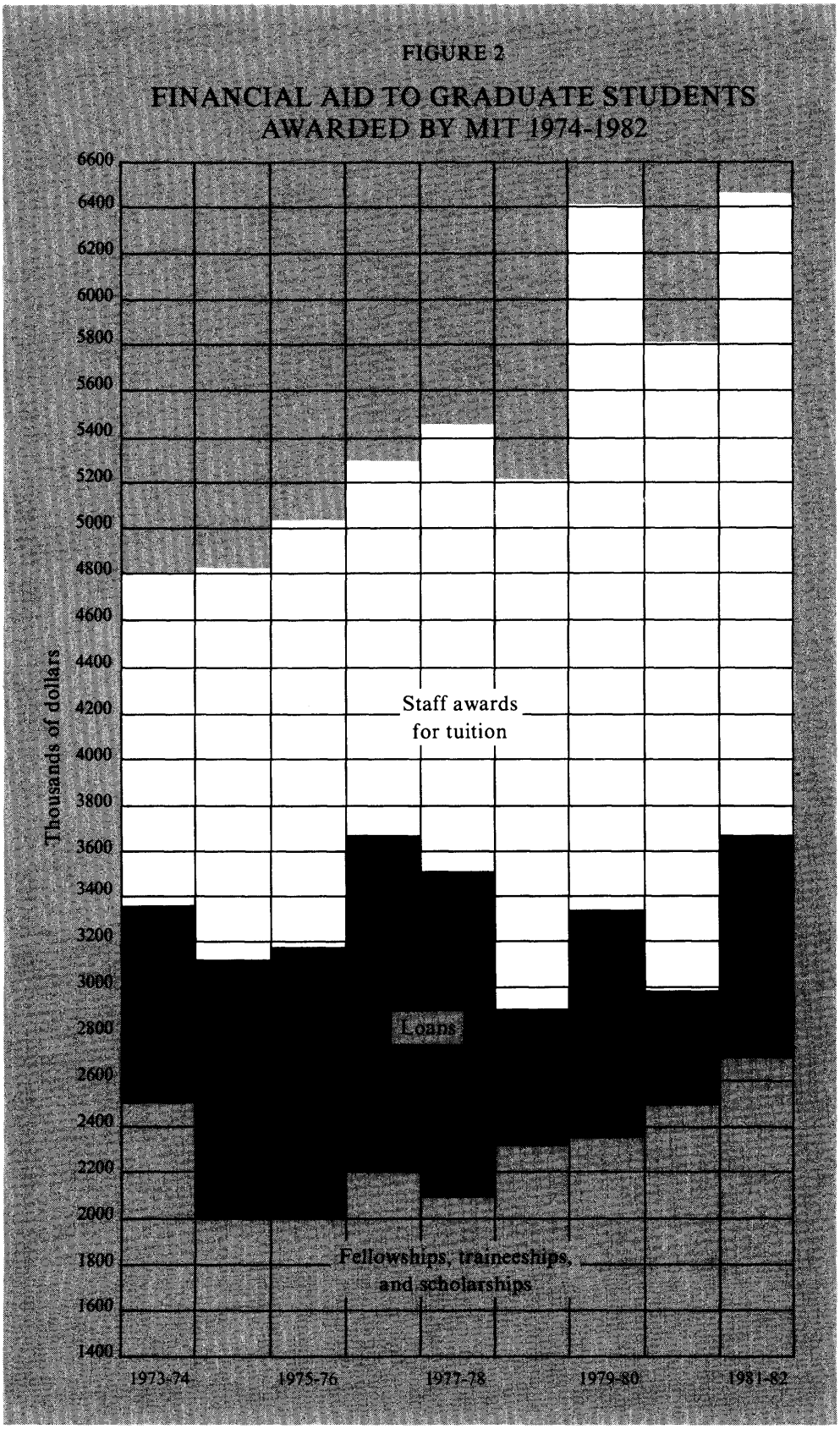
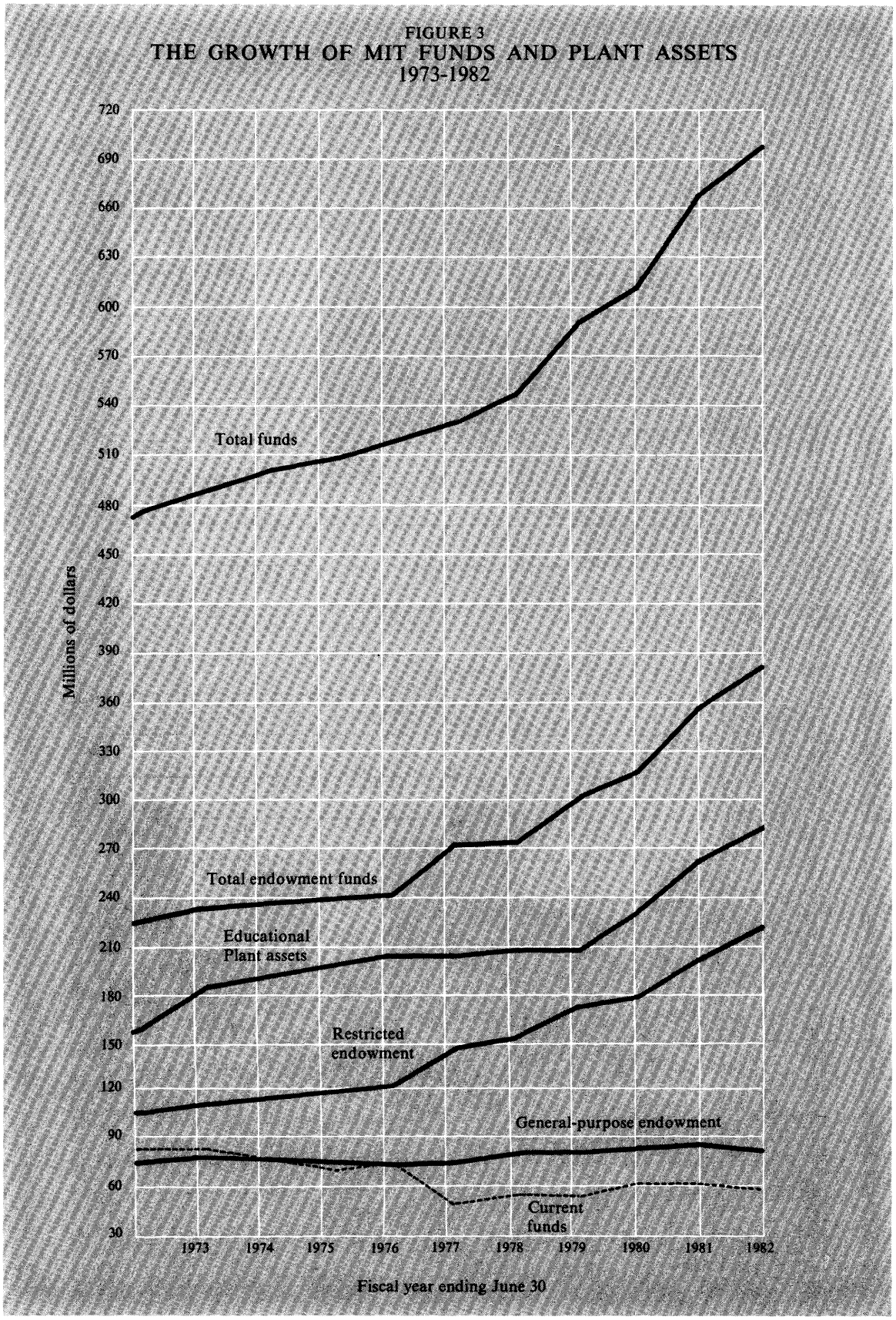


FIGURE 3
THE GROWTH OF MIT FUNDS AND PLANT ASSETS
1973-1982



Personnel Changes

CORPORATION

DEATHS

Edward J. Hanley
Life Member, Emeritus

Charles Allen Thomas
Life Member, Emeritus

CHANGES OF APPOINTMENT

W. Gerald Austen
Life Member

W. Van Alan Clark
Life Member

Kenneth J. Germeshausen
Life Member

W. B. Murphy
Life Member, Emeritus

ELECTIONS

Yaichi Ayukawa
Member

David R. Clare
Member

Bernard W. Harleston
Member

David I. Kosowsky
Member

Angus N. MacDonald
Member

Jerry McAfee
Member

E. Kirkbride Miller
Member

Rita A. O'Brien
Member

Frank Press
Member

Edward T. Thompson
Member

Frank S. Wyle
Member

Heidi R. Wyle
Member

MEMBERS EX-OFFICIIS

John H. Lawson
Commissioner of Education
Commonwealth of Massachusetts

Denman K. McNear
President
Alumni Association

TERMS EXPIRED

Vincent S. Castellano
Member

Charles G. Koch
Member

F. Richard Meyer
Member

David S. Saxon
Member

FACULTY

DEATHS

Charles E. Holt III
Professor in Biology

Roy Kaplow
Professor in Materials Science and Engineering

RETIREMENTS

John M. Biggs
Professor in Civil Engineering

Wilbur Davenport
Professor in Electrical Engineering and Computer Science

E. Eugene Larrabee
Associate Professor in Aeronautics and Astronautics

John F. McCarthy, Jr.
Professor in Aeronautics and Astronautics

Leo B. Moore
Professor in Sloan School of Management

RESIGNATIONS

Professors

Paul O. Roberts
Civil Engineering

Edward I. Solomon
Chemistry

George M. Whitesides
Chemistry

Associate Professors

Leonard M. Adelman
Mathematics

William I. Bennett
Humanities

Michael J. Bevan
Biology

Judith Bostock
Physics

Rowland M. Cannon, Jr.
Materials Science and Engineering

Dorian M. Goldfeld
Mathematics

Hilary M. Irvine
Civil Engineering

Peter G. W. Keen
Sloan School of Management

*From July 1, 1981, to June 30, 1982

James H. McClellan
Electrical Engineering and
Computer Science

Nathaniel J. Mass
Sloan School of Management

Philip C. Myers
Physics

Vaughan R. Pratt
Electrical Engineering and
Computer Science

Frederick A. Putnam
Chemical Engineering

William H. Rastetter
Chemistry

Ellen B. Voigt
Humanities

Andrew J. Wiles
Mathematics

John L. Wilson III
Civil Engineering

Assistant Professors

James W. Driscoll
Sloan School of Management

Fred M. Gelbard
Chemical Engineering

Jawaid A. Ghani
Sloan School of Management

Frederick Hodgson
Humanities

Robert B. Litterman
Economics

F. Read McFeeley
Chemistry

Hassan Minor
Urban Studies and Planning

Raymond T. Pierrehumbert
Meteorology and Physical
Oceanography

Shelley L. Rasmussen
Mathematics

Thomas J. Teisberg
Economics

Clifton L. West III
Athletics

Herbert M. Wood
Chemical Engineering

Barry Zevin
Architecture

PROMOTIONS

To Professor:

Arthur B. Baggeroer
Ocean Engineering

Louis B. D. Braida
Electrical Engineering and
Computer Science

John M. Edmond
Earth and Planetary Sciences

Leon Groisser
Architecture

Wesley L. Harris, Sr.
Aeronautics and Astronautics

Victor Kac
Mathematics

Ronald M. Latanision
Materials Science and Engineering

Barbara H. Liskov
Electrical Engineering and
Computer Science

Eric S. Maskin
Economics

Francois M. M. Morel
Civil Engineering

Karen R. Polenske
Urban Studies and Planning

Saul A. Rappaport
Physics

John B. Vander Sande
Materials Science and Engineering

Michelle Vergne
Mathematics

James H. Williams, Jr.
Mechanical Engineering

To Associate Professor:

Dimitri A. Antoniadis
Electrical Engineering and
Computer Science

Lewis Erwin
Mechanical Engineering

Henry S. Farber
Economics

David H. Friedman
Architecture

A. Rae Goodell
Humanities

Stephen C. Graves
Sloan School of Management

H. Robert Horvitz
Biology

Paul K. Houpt
Mechanical Engineering

Roger D. Kamm
Mechanical Engineering

Robert S. Langer
Nutrition and Food Science

Michael P. Manning
Chemical Engineering

Gary L. Miller
Mathematics

Kim Molvig
Nuclear Engineering

Christos H. Papadimitriou
Electrical Engineering and
Computer Science

David M. Parks
Mechanical Engineering

Alician V. Quinlan
Mechanical Engineering

Michael M. Salour
Electrical Engineering and
Computer Science

Yosef Sheffi
Civil Engineering

William T. Thompkins, Jr.
Aeronautics and Astronautics

Costas G. Vayenas
Chemical Engineering

Robert J. Van Houten
Ocean Engineering

David A. Vogan
Mathematics

Martin B. Zimmerman
Sloan School of Management

To Assistant Professor:

A. Thomas Ferguson
Political Science

Andrew C. Fowler
Mathematics

Jeffry N. Kahn
Mathematics

Peter Perdue
Humanities

Martha Rosner
Nutrition and Food Science

CHANGES OF APPOINTMENT

Robert A. Alberty
Professor in Chemistry

Jonathan Allen
Director of Research Laboratory of Electronics and Professor in Electrical Engineering and Computer Science

Alan A. Altshuler
Professor in Political Science

Lallit Anand
Assistant Professor in Mechanical Engineering

Wayne V. Andersen
Adjunct Professor in Architecture

David B. Ashley
Research Associate in Civil Engineering

Amr S. Azzouz
Assistant Professor in Civil Engineering

Julian Beinart
Department Head (Interim), Architecture and Professor in Architecture

Donald L. M. Blackmer
Department Head in Political Science and Professor in Political Science

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

Peter Buck
Associate Professor in Program in Science, Technology, and Society

Chryssostomos Chryssostomidis
Acting Department Head in Ocean Engineering and Associate Professor

Suzanne H. Corkin
Associate Professor in Psychology

John P. de Monchaux
Dean of the School of Architecture and Planning and Professor in Architecture and Urban Studies and Planning

John M. Deutch
Dean of the School of Science and Arthur C. Cope Professor in Chemistry

Andrea A. di Sessa
Principal Research Scientist in Laboratory for Computer Science

Fernando P. Domeyko
Associate Professor in Architecture

Ira Dyer
Professor in Ocean Engineering

Peter Elias
Acting Associate Department Head for Computer Science and Engineering and Edwin S. Webster Professor of Electrical Engineering

Lloyd S. Etheredge
Research Associate in Political Science

Ann F. Friedlaender
Associate Department Head in Economics and Professor of Economics and Civil Engineering

Philip M. Gschwend
Assistant Professor in Civil Engineering

Alan Guth
Associate Professor in Physics

N. John Habraken
Professor in Architecture

Morris Halle
Institute Professor

Kent F. Hansen
Professor in Nuclear Engineering

Michael F. Holick
Associate Professor in Nutrition and Food Science

David G. Jansson
Lecturer in Mechanical Engineering and Director of the MIT Innovation Center

Carl Kaysen
Director of Program in Science, Technology, and Society and David W. Skinner Professor of Political Economy

Roman Krzysztofowicz
Research Associate in Civil Engineering

Roy Lamson
Secretary, Council for the Arts

Benjamin Lax
Professor in Physics

Victor C. Li
Assistant Professor in Civil Engineering

Edward Lorenz
Professor in Meteorology and Physical Oceanography

Tomaso Lozano-Perez
Assistant Professor in Electrical Engineering and Computer Science

James W. Mar
Department Head in Aeronautics and Astronautics and Jerome C. Hunsaker Professor of Aerospace Education

Jeffrey A. Meldman
Senior Lecturer in Sloan School and Associate Dean for Student Affairs

Sanjoy K. Mitter
Director of Laboratory for Information and Decision Systems and Professor in Electrical Engineering and Computer Science

Michael Modell
Visiting Lecturer in Chemical Engineering

Joel Moses
Department Head in Electrical Engineering and Computer Science and Professor of Computer Science

Richard C. Mulligan
Assistant Professor in Biology

T. Francis Ogilvie
Department Head in Ocean Engineering and Professor of Ocean Engineering

Ruth Perry
Lecturer in Humanities

Stephen B. Pope
Lecturer in Mechanical Engineering

William L. Porter
Professor in Architecture and Urban Studies and Special Assistant to the President for the Arts

Rudrapatna Ramnath
Adjunct Professor in Aeronautics and Astronautics

Norman C. Rasmussen
Professor in Nuclear Engineering

Robert N. Scanlan
Lecturer in Humanities

John G. Sclater
MIT Director of the Joint MIT-WHOI Program and Professor in Earth and Planetary Sciences

Paul D. Sclavounos
Assistant Professor in Ocean Engineering

Michael S. Scott Morton
Professor of Management in Sloan School of Management

Robert C. Seamans, Jr.
Henry R. Luce Professor of Environment and Public Policy in the Office of the Provost

Alvin J. Silk
Associate Dean and Professor of Management Science in Sloan School of Management

Kenneth A. Smith
Associate Provost and Vice President for Research and Professor in Chemical Engineering

Stephen G. Steadman
Senior Research Scientist in Physics

Peter H. Stone
Department Head in Meteorology and Physical Oceanography and Professor of Meteorology

Neil E. Todreas
Department Head in Nuclear Engineering and Professor of Nuclear Engineering

Hoo-Min D. Toong
Research Associate in Sloan School of Management

Shimon Ullman
Associate Professor in Psychology

Gerald L. Wilson
Dean of the School of Engineering, Philip Sporn Professor of Energy Processing in Electrical Engineering and Computer Science, and Director, Electric Power Systems Engineering Laboratory

Peter A. Wolff
Director of the Francis Bitter National Magnet Laboratory and Professor in Physics

Carl Wunsch
Professor in Earth and Planetary Sciences

Joel R. Yellin
Senior Research Scientist in Program in Science, Technology, and Society

NEW FACULTY APPOINTMENTS

Professors

Howard Brenner
Willard Henry Dow Professor in Chemical Engineering

Robert D. Rosenberg
Biology

Susumu Tonegawa
Biology

Associate Professors:

William I. Bennett
Humanities

Jane Coppock
Humanities

Linn W. Hobbs
Materials Science and Engineering

Tomaso Poggio
Psychology

Ulrich W. Suter
Chemical Engineering

Andrew J. Wiles
Mathematics

Assistant Professors

David L. Akin
Aeronautics and Astronautics

Triantaphyllos Akylas
Mechanical Engineering

Montgomery M. Alger
Chemical Engineering

Haruhiko Asada
Mechanical Engineering

Ronald G. Ballinger
Nuclear Engineering/ Materials Science and Engineering

Gian P. Beretta
Mechanical Engineering

John F. Brady
Chemical Engineering

Sylvia T. Ceyer
Chemistry

Suzanne DeAtley
Humanities

John Dreher
Physics

David J. Edell
Harvard-MIT Division of Health Sciences and Technology/ Electrical Engineering and Computer Science

Kerry A. Emanuel
Meteorology and Physical Oceanography

John R. Freeman
Political Science

Barbara Gastel
Humanities

Leonard P. Guarente
Biology

Timothy G. P. Gutowski
Mechanical Engineering

Nabeel Hamdi
Architecture

Joseph H. Haritonidis
Aeronautics and Astronautics

Trevor A. Hatton
Chemical Engineering

James E. Hubbard, Jr.
Mechanical Engineering

David S. Jerison
Mathematics

Gretchen Kalonji
Materials Science and Engineering

Philip Khoury
Humanities

Monty Krieger
Biology/Whitaker College of Health Sciences, Technology, and Management

Paul A. Lagace
Aeronautics and Astronautics

Daniel Metlay
Political Science

Carolyn F. Moyer
Nutrition and Food Science/ Division of Comparative Medicine

Terry P. Orlando
Electrical Engineering and Computer Science

Candace L. Royer
Athletics

Kenneth R. Sloan, Jr.
Architecture

John D. Sterman
Sloan School of Management

S. Shyam Sunder
Civil Engineering

Sharon Traweek
Humanities/Program in Science, Technology, and Society

Ming-Kai Tse
Mechanical Engineering

Bruce K. Walker
Aeronautics and Astronautics

Gordon B. M. Walker
Sloan School of Management

Adjunct Professors

Alan S. Michaels
Chemical Engineering

Joseph L. Russell
Chemical Engineering

Maurice V. Wilkes
Electrical Engineering and Computer Science

VISITING FACULTY

Visiting Professors

Abraham Ben-Arroyo
Civil Engineering

Barry Berman
Physics

Michael Bruno
Economics

C. Tyler Burge
Linguistics and Philosophy

Francoise Choay
Architecture

Patricia Craddock
Humanities

John F. Davidson
Chemical Engineering

Themistocles Dracos
Civil Engineering

Bengt Edman
Architecture

Benjamin Epstein
Mathematics

Gunner Fant
Electrical Engineering and Computer Science

Richard E. Garrett
Mechanical Engineering

Julian Gresser
Program in Science, Technology, and Society

Joel S. Hetland
Aerospace Studies

Rui-Hua Hu
Ocean Engineering

Adel A. Ismail
Architecture

Gerhard Kallmann
Architecture

Peter K. Manning
Sloan School of Management

Piravonu M. Mathews
Physics

Peter McCleary
Architecture

Glenn M. Nagel
Biology

Dale J. Poirier
Economics

R. Ronald Rau
Physics

Kevin W. S. Roberts
Economics

Vittorio Sgaramella
Chemistry

Julius L. Shaneson
Mathematics

Robert J. Shiller
Economics

Hermina J. Sinclair
Division for Study and Research in Education

G. Sidney Smith
Military Science

Michael Solomon
Earth and Planetary Sciences

Jerzy Soltan
Architecture

Gordon Sparks
Economics

Werner Stuetzle
Mathematics

Ian O. Sutherland
Chemistry

Peter Swiggart
Humanities

Jean Valentine
Humanities

Richard P. Von Herzen
Earth and Planetary Sciences

Christoph Wehrli
Aeronautics and Astronautics

Tomasz Wierzbicki
Ocean Engineering

Visiting Associate Professors

Peter Breitenlohner
Mathematics

Michael H. Burgoyne
Architecture

Avishai Ceder
Civil Engineering

Shan Cretin
Sloan School of Management

Henry J. B. Dick
Earth and Planetary Sciences

Julius Kuti
Physics

Lee-Or Merkine
Meteorology and Physical Oceanography

Naomasa Nakajima
Mechanical Engineering

Robert A. Peura
Harvard-MIT Division of Health Sciences and Technology

Elizabeth Pleck
Humanities

Philip Roseneau
Nuclear Engineering

Cornelius W. Sullivan
Civil Engineering

Charles Van Loan
Electrical Engineering and Computer Science

Ditmar K. Winje
Nuclear Engineering

Visiting Assistant Professors

Robert Bruegmann
Architecture

Allan S. Detsky
Harvard-MIT Division of Health Sciences and Technology

William W. Doerr
Chemical Engineering

Ellen Fitzpatrick
Humanities

Acmi M. Ishaq
Civil Engineering

Valerie I. Nelson
Urban Studies and Planning

Jack Patrick
Architecture

Louise B. Popkin
Humanities

Sushila Rao
Sloan School of Management

Edwina L. Rissland
Division for Study and Research in Education

Ellen C. Rose
Humanities

Brian Saunders
Humanities

AWARD

Chia-Chiao Lin
Institute Professor; Killian Award Lecturer for the Academic Year 1981-82

ADMINISTRATION

DEATHS

Frank O. Melanson
Senior Systems Analyst
Information Processing Services

RETIREMENTS

Johanna B. Bond
Assistant to the Registrar
Registrar's Office

Peter P. Gil
Associate Dean and Senior Lecturer
Sloan School of Management

Patricia M. Sheehan
Library Systems Designer
Libraries

John Woodbury
Assistant Director, Housing
Housing and Food Services

Frederic G. Worden
Director, Neurosciences Research Program

RESIGNATIONS

Donald R. Aertker
Archival/Manuscript Specialist
Libraries

Clare S. Beard
Applications Programmer
Information Processing Services

Jill E. Bolin
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Comptroller's Accounting Office

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Physical Plant

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Office of the Dean for Student Affairs

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Martha L. Newton
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Elaine Petrino
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Alumni Association

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Purchasing and Stores

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Administrator, Psychiatric and Social Work Service
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Libraries

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Office of the Vice President

Diane E. Tenen
Senior Staff Accountant
Comptroller's Accounting Office

Alice W. Tripp
Program Coordinator
Office of the Director
Resource Development

Therese M. Viohl
Assistant Manager, Wage and Salary
Personnel Office

Linda E. Ward
Administrative Officer
Center for Advanced Engineering Study

Jayne K. West
Senior Programming Analyst
Information Processing Services

Ann White
Senior Programming Analyst
Information Processing Services

Sally A. Zinno
Operations Manager
Medical Department

APPOINTMENTS

Kenneth R. Auerbach
Programming Analyst
Information Processing Services

Dorothea Ross Black
Production Manager, Design Services
Campus Information Services

Thomas Allen Blackson
Programming Analyst
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Barbara M. Brennan
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Office of Facilities Management Systems

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Industrial Liaison Program

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Numerical/Statistical Analyst
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Rocklyn E. Clarke
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Information Processing Services

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Assistant Bursar/Student Accounts
Bursar's Office

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Industrial Liaison Officer
Industrial Liaison Program

Dorothy Desimone
Librarian
Libraries

Walter G. Diaz
Safety Assistant
Safety Office

Luise Flavin
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Office of the Vice President, Operations

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Treasurer's Office

Mark Adam Gorenstein
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Medical Department

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Inez B. Hazel
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Maureen P. Hedden
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Industrial Liaison Program

Beni Inouye
Assistant Director, Industrial Liaison Program and Director of MIT-ILP Tokyo
Industrial Liaison Program

Linda F. Jonash
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Planning Office

Timo I. Kasslin
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Nancy J. Kaufer
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Libraries

Cynthia Louisa Konick
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Irene Leamon
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Information Processing Services

Anne Leedham
Applications Programmer
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Robert Lockett
Industrial Liaison Officer
Industrial Liaison Program

Loree A. Mahoney
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Comptroller's Accounting Office

Susan Marcotte-Jenkins
Administrative Officer
Division of Comparative Medicine

Kathleen Marquis
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Libraries

Stanley J. Michalak
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Information Processing Services

Kevin J. Milligan
Property Auditor
Office of Facilities Management Systems

Robert J. Monnar
Purchasing Agent
Office Of Laboratory Supplies

Richard H. O'Connell
Senior Systems Analyst
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John E. Oldham
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Marlene Ostrowski
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Pamela A. Phillips
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Social Work Services
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Beverley A. Robbins
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Purchasing and Stores

Kathleen Romano
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Department of Nuclear Engineering

Marcia Ryder
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Operations Research Center

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Lucinda L. Smith
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School of Engineering

Judith Sobel
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Barbara G. Stowe
Development Officer in Health Sciences
Office of the Vice President, Resource
Development

Judith Y. Symolon
Child Care Counselor
Office of the Vice President

Robert E. Travis
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Comptroller's Accounting Office

Margaret D. Tyler
Assistant to the Director
Office of Admissions

Katherine E. Van Sant
Industrial Liaison Officer
Industrial Liaison Program

Linda Vaughan
Assistant Dean for Student Affairs,
Student and Assistance Services
Office of the Dean for Student
Affairs

Arthur R. Wagman
Bursar
Bursar's Office

Donna E. Webber
Assistant Archivist
Libraries

Pm Weizenbaum
Technical Writer
Information Processing Services

Lenis H. Williams
Librarian
Libraries

CHANGES

Jeffrey A. Barks
Director of Degree Programs
Sloan School of Management

Sharon Basco-Koch
Acquisitions Editor
MIT Press

Donna M. Behmer
Operations Coordinator
Sloan School of Management

Paul L. Bergonzi
Staff Accountant
Comptroller's Accounting Office

John B. Bidwell
Data Base Manager
Alumni Association

John T. Blake
Area Manager
Information Processing Services

Jean C. Bonney
Associate Director
Information Processing Services

Peter J. Boisvert
Senior Applications Programmer
Information Processing Services

Francis L. Bowes
Government Property Officer
Office of Facilities Management
Systems

Elizabeth C. Bradley
Assistant to the Registrar
Registrar's Office

Ann M. Brazier
Manager
Quarter Century Club

Carolyn H. Brooke
Administrative Assistant
Department of Ocean Engineering

Donald E. Brown
Staff Accountant
Comptroller's Accounting Office

David W. Burleigh
Senior Programming Analyst
Information Processing Services

Mary E. Bushnell
Document Manager, Administrative
Information Systems
Information Processing Services

David M. Carney
Manager, Financial Planning and
Procedures
Information Processing Services

Kathleen E. Carney
Senior Applications Programmer
Information Processing Services

Francis A. Chandler
Coordinator of Special Projects
Alumni Association

Paulette P. Chiles
Administrative Assistant
Department of Civil Engineering

Marjorie W. Chryssostomidis
Librarian
Libraries

Isaac M. Colbert
Manager, Faculty and Staff
Information Services
Personnel Office

Francis T. Conroy
Audit Supervisor
Audit Division

Lisa Cornelisse
Assistant Science Librarian
for Reference
Libraries

Melinda A. Costello
Staff Administrator
Purchasing and Stores

Joanne L. Cummings
Assistant to the Director for
Administration
Ofice of Admissions

Josephine M. DiCicco
Information Manager
Sloan School of Management

William R. Dickson
Senior Vice President

Judith E. DiGennaro
Information Retrieval Manager
Alumni Association

Patricia A. Dixon
Administrative Assistant
Department of Civil Engineering

Kristin N. Djorup
Librarian
Libraries

Judith M. Douglis
Assistant Director
Housing and Food Services

Lynne A. Dowling
Systems Programmer
Information Processing Services

Donna L. Dudley
Staff Accountant
Comptroller's Accounting Office

Jeanne A. Duperreault
Librarian
Libraries

Bethany J. Easter
Librarian
Libraries

Rodney A. Edwards
Supervisor, Medical Records Services
Medical Department

Clare M. Egan
Administrative Assistant
Department of Nuclear Engineering

Sharon K. Everson
Senior Numerical/Statistical Analyst
Information Processing Services

Ray E. Faith
Computer Services Coordinator
Information Processing Services

Kathleen Finklestein
Manager of Administrative Operations
Alumni Association

William J. Fitzgerald
Area Manager
Information Processing Services

Peter H. Flagg
Area Manager
Information Processing Services

James T. Gabbert, Jr.
Coordinator, Master's Program
Sloan School of Management

Steven Gass
Librarian
Libraries

Jeannette L. Gerzon
Assistant Dean for Student Affairs
and Advisor on Preprofessional
Education
Office of the Dean for Student Affairs

Karen H. Goodall
Child Care Administrator
Office of the Vice President,
Operations

Sarah H. Gramenz
Librarian
Libraries

Robert P. Greene
MIT/TAP Representative
Provost's Office

David E. Griffin
Applications Programmer
Information Processing Services

Daniel H. Gould
Assistant to the Provost for
Administration in the Office of the
Provost and Executive Officer in
the Department of Physics

Brenda Hambleton
Assistant Director
Office of Admissions

Sheila M. Hayes
Administrative Officer
Center for Advanced
Engineering Study

Inez B. Hazel
Systems Programmer
Information Processing Services

Donald E. Heller
Supervisor, Purchasing Support
Services Group
Purchasing and Stores

Deborah A. Hoover
Executive Director, Council for
the Arts at MIT
Office of the President

Kate S. Herzog
Librarian
Libraries

Barbara Jo Hughes
Senior Programming Analyst
Information Processing Services

Nancy B. Ibsen
Applications Programmer
Information Processing Services

Kristin K. Janghorbani
Assistant Barker Librarian
Libraries

Patricia A. Kane
Manager of Financial Operations
Alumni Association

Mary M. Kelly
Assistant to the Director for
Data Base Management and
Freshman Processing
Office of Admissions

Charles N. Kennedy
Technical Writer
Information Processing Services

Lawrence W. Killian
Direct Mail and Advertising Manager
MIT Press

Judith F. Klayman
Assistant Operations Manager
Medical Department

Carol A. LaPointe
Administrative Assistant
Department of Ocean Engineering

Susan A. Lester
Assistant Manager, Wage and
Salary Administration
Personnel Office

Olga Levshin
Programming Analyst
Information Processing Services

Anne W. Lipner
Director, Finance and Administration
Sloan School of Management

Thomas A. Lynch
Operations Administrator
Department of Biology

Kenneth MacAskill
Maintenance Safety Coordinator
Medical Department

Karl LeRoy Mapes
Area Manager
Information Processing Services

Mary Markunas
Claims Administrator, MIT Health Plan
Medical Department

Robert F. Matson
Senior Systems Analyst
Information Processing Services

James H. McCarthy
Assistant to the Director
Center for Policy Alternatives

Timothy J. McGovern
Senior Systems Analyst
Information Processing Services

Junko E. McLean
Grant and Contract Administrator
Earth and Planetary Sciences

Julia C. McLellan
Senior Associate Director of Admissions
Office of Admissions

Marilyn A. McMillan
Area Manager
Information Processing Services

Walter L. Milne
Assistant to the Chairman and
to the President

Diane Monahan
Records Maintenance Manager
Alumni Association

Jean E. Morin
Administrative Assistant
Provost's Office

Doreen Morris
Financial Officer
School of Science

John B. Morway
Administrative Officer
Department of Physics

Elizabeth K. Mulcahy
Assistant Manager, Faculty and
Staff Information Services
Personnel Office

Kathleen A. Murphy
Journals Circulation Manager
MIT Press

Eric M. Ostrom
Computer Systems Manager
Department of Electrical Engineering
and Computer Science

Claire L. Paulding
Assistant Manager, Faculty and
Staff Information Services
Personnel Office

Evelyn L. Perez
Assistant to the Dean,
Personnel Administration
School of Science

August Perry
Manager, Campus Housing
Maintenance
Housing and Food Services

George N. Petievich
Assistant Director, Operations
and Systems
Medical Department

Philip L. Philips
Assistant Accounting Officer
Comptroller's Accounting Office

Shirley M. Picardi
Secretary of the Alumni Association
Alumni Association

George T. Plew
Assistant to the Bursar
Bursar's Office

Sharman S. Randall
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Social Work Services
Medical Department

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Manager, Internal Operations
Alumni Association

Pauline J. Reynolds
Accounting Officer
Comptroller's Accounting Office

Joan F. Rice
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Development
Personnel Office

Marco Sarmiento
Senior Systems Analyst
Information Processing Services

Rose S. Scanlon
Conference Coordinator
Office of Facilities Management
Systems

Marjorie E. Sciulli
Staff Accountant
Comptroller's Accounting Office

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Computing Services
Information Processing Services

Robert M. Shaw
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Information Processing Services

Thomas M. Shea
Senior Systems Analyst
Information Processing Services

Garrett L. Sheldon
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Systems Technical Services
Information Processing Services

Robert A. Slauzis
Staff Accountant
Comptroller's Accounting Office

Janet L. Snover
Communications Manager
Campus Information Services

Stanley W. Sundstrom
Systems Analyst
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Holly B. Sweet
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Experimental Study Group

Donna J. Taylor
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Robert D. Taylor
Institute Property Officer
Office of Facilities Management
Systems

Diane E. Tenen
Senior Staff Accountant
Comptroller's Accounting Office

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Development
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Architect-Building, Program and Design
Physical Plant

Nancy R. Urquhart
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Serials Cataloguer
Libraries

Herkus W. VonLetkemann II
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Bonnie J. Walters
Assistant to the Department Head
Department of Humanities

Philippa Warner
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Office of the Vice President, Operations

Susan Warshauer
Staff Development Specialist
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Janet M. Wright
Assistant Operations Manager
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Dorothy Zaborowski
Numerical/Statistical Analyst
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Provost

Center for Advanced Visual Studies

The Center for Advanced Visual Studies (CAVS) was formed in 1967 by Professor, Emeritus Gyorgy Kepes. Dedicated in 1968, it has been directed by Professor Otto Piene since 1974. During its lifespan of 14 years it has hosted 85 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 Master of Science in Visual Studies program presented such topics as "Inquiries into the Biomirror" (Todd Siler), "Autobiographical Constructions" (Peter Codella), and "Radio Frequency Performance" (Ken Kantor). An outstanding subject among CAVS educational offerings has been "The Artists Speak -- Work of the Fellows of the CAVS."

The series of video programs and presentations, "Centervideo," concluded at the SIGMA Bordeaux, France, festival. It was introduced by Professor Piene and commented on and presented by video artist/Fellow Betsy Connors.

A celebrative event, "Festival of Lights," was provided by laser artist/composer Paul Earls and festival designer/artist Antoni Miralda, in collaboration with Professor Piene, for the gala opening of the new engineering building of Corning Glassworks in Corning, NY.

Many CAVS Fellows participated in the DeCordova Museum's (Lincoln, MA) 1982 "Festival of the Future."

The focal event of the 1981-82 year at CAVS was the Sky Art Conference '81, co-directed by Professor Piene and Elizabeth Goldring, CAVS Fellow, and chaired by Institute Professor, Emeritus Harold Edgerton. It hosted scientists, scholars, artists, and fliers from the United States and abroad for presentations, panels, and events on the theme of the cultural mission in sky and space. The concept of sky art has been primarily developed at CAVS during the past 15 years.

The following is a brief sampling of individual work and achievements by CAVS Fellows throughout the year: Harriet Casdin-Silver, who received a fellowship from the Rockefeller Foundation, was a consultant for the Foundation on the future of holography, and participated in "Space Light," at the Power House Museum, Sydney, Australia.

Ms. Connors participated in "Four from CAVS" (with Elliott V. Grabill, Bernd Kracke, Wendelin Glatzel) at Anthology Film Archives, New York City, 1982, and in "Phoenix" for the opening of the Alte Oper, Frankfurt, Germany.

Joe Davis developed a personal artistic program for the NASA Space Shuttle and signed the first artist's payload agreement (several additional payload reservations for CAVS have been agreed upon).

Mr. Earls had a laser/music/multimedia installation and series, "modulations," at the MIT Hayden Gallery, 1982.

Mr. Grabill received a Massachusetts Artists Foundation Fellowship in 1982. He co-organized the "Festival of the Future" at the DeCordova Museum.

Marek Holynski came to CAVS with a Kosciuszko Foundation award in 1981 and received the Best Scientific Book of the Year Award in Poland, for his book on artificial intelligence.

Setsuko Ishii exhibited her holographic images in Taipei, Taiwan, and Venice, Italy, and at the Musee de l'Holographie in Paris.

Chris Janney performed his dance-and-electronics pieces, "Soundstair" and "Steamshuffle," in Rome, Italy; Essen, Germany; and at the Second International Electronic Music Festival in Brussels, Belgium. He contributed to the "Wall-to-Wall John Cage and Friends" celebration in New York City in 1982.

Piotr Kowalski had a celebrated one-man exhibition, "Time Machine + Projects," at the Centre Georges Pompidou/"Beaubourg" in Paris, 1981-82. He, together with Professor Kepes and Mr. Siler, was among the participants in the exhibition, "ALEA(S)," at "ARC 2," Musee d'Art Moderne de la Ville de Paris in 1982.

Mr. Kracke conceived of and cooperated in "Data Network" at the Sky Art Conference '81. He participated in "Four from CAVS" at the Anthology Film Archives, New York City, 1982, and in "Videokunst in Deutschland, 1963-1982" at the Koelnischer Kunstverein in Cologne, Germany, in 1982.

Antonio Muntadas contributed extensively to XVI Bienal de Sao Paulo, Brazil, in 1981.

Ian Strasfogel co-produced and directed Kandinski's "Der Gelbe Klang" for the Solomon R. Guggenheim Museum, New York City, 1981-82. He is currently engaged in preparing a stage version of "Icarus," with and by Mr. Earls and Professor Piene for the 1982 Sky Art Conference and the Alte Oper, in Frankfurt, Germany.

Professor Piene has prepared and co-organized the 1981 and 1982 Sky Art conferences (the 1982 Conference is to be held in Linz, Austria, hosted by the ARS ELECTRONICA/BrucknerFest). He gave a performance/installation for the opening of the Alte Oper, Frankfurt, Germany, in 1981; he was a principal contributor to the European Graphics Biennale in Baden-Baden, Germany, in 1981; and he provided sky events for festivals, conferences, and exhibitions in the US and abroad.

CAVS received grants from the National Endowment for the Arts, the Massachusetts Council on the Arts and Humanities, the MIT Council for the Arts, and the New England Foundation for the Arts (for a series of Sky Art exhibitions, 1982-84). Important support of art work was given to CAVS artists by the MIT Council for the Arts and to CAVS media-artists by MIT through their use of the Educational Video Resources studios.

The Sky Art Conference '81 catalogue accompanied the conference. It was edited by Professor Piene with CAVS Fellows Lowry Burgess, Ms. Goldring, and Mr. Kracke. Numerous reviews of the Sky Art Conference and of CAVS Fellows' work, as well as articles in books, periodicals, and newspapers and media coverage, nationally and internationally, reflected Center work and individual work at CAVS.

OTTO PIENE

Center for Cognitive Science

INTRODUCTION

The single most important event to affect the Center for Cognitive Science during the past academic year has been the award of a grant of $2.5 million from the Sloan Foundation. This funding will enable the Center to develop and expand its program of research on the general question of mental representation of human knowledge. Among the important initiatives that this grant

has made possible is faculty development. A number of research projects in the areas of vision and language acquisition have begun to be supported, and the Center has initiated a process leading to the development of a set of research goals to be achieved over the next five-year period.

The Human Subjects Laboratory continues to grow and take shape. Whereas no such laboratory existed at MIT prior to this past year, the Center is now well into the creation of an experimental facility, not only unique to MIT, but also one which promises to offer experimental capabilities not found elsewhere in the country, particularly in the areas of speech perception experimentation. Cooperation between the Center and the MIT Speech Group in the Research Laboratory of Electronics has made this possible.

There have been major initiatives in curriculum development and the postdoctoral fellowship program has continued. Finally, a predoctoral program has been initiated, aimed at the support of advanced students in cognitive science.

CURRENT SPONSORED RESEARCH

In this section sponsored research currently being conducted within the Center is briefly described. This does not include research by members of the Center and visiting postdoctoral fellows.

The Use of Intonation in Automatic Speech Understanding (Sponsoring agency: National Science Foundation; Principal Investigator: Janet Pierrehumbert). A given sentence can have many different intonation patterns, depending on the stress pattern and choice of melody. This research is directed toward developing a computer program for recovering an abstract representation of intonation from the fundamental frequency contour. This is a case study in automatic speech recognition, which may provide precedents for designing a system to label speech segments in continuous speech. Analysis of fundamental frequency may also provide information about stress and phrasing which is useful in such a system.

Grammatical Representation and Grammatical Processing (Sponsoring agency: National Science Foundation; Principal Investigators: Joan Bresnan and Ronald Kaplan). Research on this project during 1981-82 resulted in several publications and papers presented at meetings. In addition to this work, Kris Halvorsen, postdoctoral fellow, and Joan Bresnan, professor of Linguistics, are currently working on defining the conditions on anaphora in terms of f-structures. A preliminary version of this work was presented at the Harvard Conference on Scandinavian Languages.

Marilyn Ford, research associate, ran four on-line sentence perception experiments to test the hypotheses embodied in the Ford, Bresnan, and Kaplan (1981) LFG-based theory of syntactic closure. Each experiment tests whether the principles given by Research Associate Marilyn Ford, Professor Bresnan, and Ronald Kaplan are invoked during initial sentence perception or play a role in production to test and refine the Ford (1980) production model. In collaboration with linguist David Nash, Ms. Ford is studying the production of Warlpiri speech. This study is designed to determine the relative importance of c-structure and f-structure representations as planning units, and builds on the syntactic work of Simpson and Bresnan (1982). In the other production study, an extremely large corpus of English spontaneous speech has been collected and will be used to examine syntactic planning in detail, so that the production model can be made more comprehensive and explicit.

Halvorsen and Kaplan have developed and implemented the parsing system for LFGs at both MIT and Xerox PARC as a research tool for modeling various psychologically motivated parsing strategies. The parser now accepts grammars in standard LFG notation, which enables us to build directly on the results of linguistic research.

Sound and Knowledge in Spoken Word Recognition (Sponsoring agency: Natural Sciences and Engineering Research Council of Canada; Principal Investigator: Jola Jakimik). This research concerns human listeners' knowledge about and processing of spoken words. Several experiments have examined the connection between knowledge of the written and spoken forms of words -- between speech and spelling. Other experiments have investigated the recognition of words in fluent speech contexts, focusing on the role of expectations.

From Shapes and Movements to Objects and Actions: A Functional Representation (Sponsoring agency: National Science Foundation; Principal Investigators: Shimon Ullman, Lucia Vaina, and Keith Nishihara). Dr. Lucia Vaina spent much of 1981-82 on research intended to be done under this grant proposal. She designed and began experiments with Dr. Harold Goodglass of the Aphasia Research Center on comparisons between movement production and movement perception. Other experiments were also developed to measure limits of the visual system for movement perception (acceleration, velocity, trajectory).

Dr. Vaina also developed and built a communication device for a quadriplegic patient (brain-stem injury) who cannot see or speak. The device consists of a small computer, a noise-based control stick, and a pitch synthesizer. The computer is programmed to search the alphabet and the patient taps "yes" or "no" to the questions of the pitch synthesizer. The efficiency of the machine has been improved by writing a program that uses the first two letters of a word as an index in a prestored vocabulary. The patient has improved to the point where the hospital is considering purchasing the device and releasing him. A version of this device may be used at Beth Israel Hospital in the intensive care unit as a postoperative communication aid.

Dr. Vaina has arranged and begun a study of visual disturbances after open heart surgery with the Cardiac Surgery Unit at Harvard Medical School and has published two papers on vision research.

OTHER CENTER ACTIVITIES

Faculty Development

The Center has participated in the appointment of Professor Steven Pinker in the Department of Psychology, a cognitive scientist currently in the Department of Psychology at Stanford University. Dr. Pinker will be joining the faculty in the fall, when he will also become a member of the Center's Working Group. His duties will include teaching and research in the Department of Psychology. In addition, he will assume charge of the development and integration of the Center's laboratory facilities into the research and teaching programs in cognitive science now under way at the Institute.

Undergraduate Major in Cognitive Science

This spring the MIT faculty approved the establishment of an undergraduate major in cognitive science to be administered through the Department of Psychology by an Interdisciplinary committee drawn from the Departments of Linguistics and Philosophy, Psychology, and Electrical Engineering and Computer Science. Students availing themselves of the major will be required to take restricted electives under various categories such as "Experimental Cognitive Psychology," "Aspects of Natural Language," "Perception," and "Philosophy of Mind," as well as an introductory subject on cognitive science and one on formal foundations.

The institution of this new major reflects the importance that cognitive science is assuming at MIT and the degree to which faculty members interested in its various aspects collaborate with each other not only in their research but also in their teaching. It might be noted that the committee which will administer this new major consists almost entirely of members of the Center's working group. Thus the Center can take a fair amount of credit for the institution of this major at MIT, an innovation which is still unique to our university but which will undoubtedly be picked up elsewhere in the near future.

Postdoctoral Fellow Program

The Center sponsored six postdoctoral fellows this year. Besides working on their own research projects, these fellows also assisted members of the Center with ongoing research projects, coordinated seminars, participated in the Occasional Paper program, and helped continue the development of the multi-user laboratory.

Predoctoral Fellow Program

Although the Center did not sponsor any predoctoral fellows this year, the Working Group did establish guidelines for a program that will begin in fall 1982. Six graduate students were competitively selected from the three departments that actively participate in the Center (Linguistics and Philosophy, Psychology, and Electrical Engineering and Computer Science). The fellowships will be restricted to third- and fourth-year graduate students whose doctoral research is supervised by a member of the Center, who have already passed their generals, and have begun their research.

Other Visitors

Several research affiliates and two visiting scientists were appointed by the Center. These appointees performed a variety of services for the Center ranging from help in the development of the multi-user laboratory facility to support on particular research projects ongoing in the Center.

Multi-User Laboratory Facility

The computer facility, under the direction of Allan Doyle, added space and equipment in 1981-82. An additional 431 square feet of space was acquired to accommodate five subject-testing stations and additional equipment. There are two new data lines from the Department of Psychology to the PDP 11/44. The 11/44 is being tied into the MIT-wide network through a CHAOS net interface. This will allow us to access other machines such as the DECsystem 20 also used by the Center. It gives us the ability to send files to other universities via the Advanced Research Projects Agency (ARPA) national net.

Several experiments have been implemented on the PDP 11/44, including Professor Bresnan's continuous lexical decision experiments. Rapid serial visual presentation experiments and the new subject testing laboratory will enable researchers to do multi-subject text-based cross-modal auditory/visual experiments.

A TEAC tape deck, to be used in audio experiments, has been acquired this year as well as an optical character reader, which is able to read typewritten or typeset text and input it to the 11/44.

There are several dictionaries now on the 11/44 containing phonetic, syllabic, orthographic, and syntactic information. These can be sorted in any desired way, making it possible to efficiently select and construct linguistic materials for experiments.

Mr. Doyle coordinated several seminars to teach the UNIX system to visitors and members of the Center. Lecturer Jeremy Wolfe has been writing a series of notes on the use of various features of the UNIX system. They are available to all users of the PDP 11/44.

Workshop on Theoretical Issues in Language Acquisition

During the fall term a workshop on language acquisition was coordinated by Judy Klavans, a postdoctoral fellow in the Department of Psychology. It was a continuation of one run by Professor Thomas Roeper of the University of Massachusetts last year when he was a postdoctoral fellow in the Center. Original ongoing research in the field of language acquisition and the relationship to current linguistic and psychological theories were discussed. Both researchers and students participated in the series.

Seminar on Language and Speech Processing

A weekly seminar was held throughout the year to encourage informal discussions on various topics relating to language and speech processing. It was coordinated by Ms. Ford and Uli Frauenfelder, postdoctoral fellow. Different speakers were invited to present their ongoing research or to lead a discussion on important issues in the field. Topics included phonetic

perception, lexical access, code switching, and sentence comprehension and production. Faculty and students from MIT and other Boston-area universities participated in the seminar.

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. The Center's function at MIT is primarily to engage in research, with a strong commitment to find funding for advanced graduate students. However, its role is broader than this. The Center has taken initiatives in bringing together faculty from throughout the Institute who share common concerns in order to provide a forum for the critical exchange of ideas and, on occasion, the development of joint work. The Center serves as a focus for many international visitors to the campus, and as a point of contact with individuals and institutions abroad. Through seminars and publications the Center also brings international issues before the MIT community.

Under its director, Professor Eugene B. Skolnikoff of the Department of Political Science, the Center has developed a major new program on environmental, health, and safety risk management issues. This program, led by Professors Ted Greenwood, Department of Political Science, and Alvin Drake, Department of Electrical Engineering and Computer Science, has been co-sponsored by the Program in Science, Technology, and Society (STS). It will explore such subjects as: scientific inputs to risk assessment, risk modeling and analysis, institutional behavior in dealing with social risks, and case studies of specific risk management applications. Faculty from throughout the Institute met during the year to develop a concrete agenda for a continuing faculty working seminar and a longer-range research program. This core group included, in addition to Professors Skolnikoff, Greenwood, and Drake, the following professors: Lawrence Bacow, Department of Urban Studies and Planning; Gregory Baecher, Department of Civil Engineering; William DuMouchel, Department of Mathematics; Joseph Ferreira, Jr., Department of Urban Studies and Planning; Stan Finkelstein, Sloan School of Management; Jeffrey Harris, Department of Economics; Carl Kaysen STS; Amadeo Odoni, Department of Aeronautics and Astronautics; Norman Rasmussen, Department of Nuclear Engineering; George Rathjens, Department of Political Science; Walter Rosenblith, Institute Professor; Jerome Rothenberg, Department of Economics; Harvey Sapolsky, Department of Political Science; Steven Tannenbaum, Department of Nutrition and Food Science; Gerald Wogan, Department of Nutrition and Food Science; and Joel Yellin, senior research scientist. Also involved were individuals from various research centers: Nicholas Ashford, Dale Hattis, George Heaton, Jr., and Christopher Hill (all of the Center for Policy Alternatives), and Laura Green, postdoctoral fellow in the Department of Nutrition and Food Science. Development of this program was funded by the Sloan Foundation and the Russell Sage Foundation.

This risk management program was based in part on the Center's work on the international aspects of toxic chemicals in the environment, funded by the Andrew W. Mellon Foundation. Dr. Subodh Mathur, postdoctoral fellow, Center for International Studies, and Professor Ann Friedlaender, Departments of Economics and of Civil Engineering, finished a study of how pollution and environmental controls affect international trade, and they explored how classical economic theory would forecast the results. Dr. Howard Margolis, postdoctoral fellow, Center for International Studies, worked on problems of "political cognition," drawing on examples from fields such as the environment, arms control, and defense policy to help explain why a policy issue may be viewed so differently by different people. The third area of research, which is still under way by Professor Rothenberg, compares the ways in which various European countries and the US deal with toxic chemicals in the environment. During the year, editorial work was completed on a volume of original essays by leaders 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 was edited by Professor Saul Friedlander, Hebrew University of Jerusalem, and coedited by Professors Skolnikoff, Gerald Holton of Harvard University and STS, and Leo Marx of STS. It will be published in 1982 by Holmes & Meier.

Closely related to the programs previously described was the comparative study being completed by Professor Greenwood of the ways in which two major US regulatory agencies -- the Occupational Safety and Health Administration and the Environmental Protection Agency -- respond to and use scientific information. Professor Greenwood's work was 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 educational program in these fields, centered in the Department of Political Science. Professor Jack Ruina, Department of Electrical Engineering and Computer Science, heads the program; other key participants are Professors William Kaufmann, Stephen Meyer, and Professors Rathjens and Greenwood, all of the Department of Political Science; Gerald Steinberg, postdoctoral fellow, Center for International Studies; Eric Kinter, research associate at the Center for International Studies; and Amelia Leiss, Center for International Studies. Two visiting scholars at the Center made major contributions during the past year: Dr. Baruch Raz, Tel Aviv University, Israel, and Major George Cull, US Air Force.

The major research themes remained the US-Soviet strategic arms balance and nuclear proliferation. Additional research during the past year included a study by Professor Meyer of Soviet decision making on weapons development and procurement. The arms control and defense policy program received its principal support from the Ford Foundation with additional funding from the Advanced Research Projects Agency of the US Department of Defense.

The Center remained 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 Pool, Department of Political Science, led the Center's part in the program, together with Professor W. Russell Neuman, Department of Political Science. Efforts continued to raise funds for additional staff, with a second career-development appointment to be made in the near future.

Funds were also 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 was sponsored by the US Agency for International Development and was being carried out in conjunction with Abt Research Associates, 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 drew upon work that was done by Professor Pool on rural communication in Egypt under the MIT Technology Adaptation Program. Professor Neuman began an analysis of the effects of new communications technology on the future of the mass audience. Support also was received for a study of the history of the computer.

The program had multiple sponsors: American Telephone and Telegraph, International Telephone and Telegraph, International Business Machines, Hughes Aircraft Corporation, Alarm Devices Manufacturing Company, Citibank, the Sloan Foundation, the Markle Foundation, and the City of Boston. Professor Neuman's work had several media and corporate sponsors: Columbia Broadcasting System; Time, Inc.; Warner Communication; and the *Washington Post*.

Energy policy remained an important focus of the Center's program. With a major endowment from the Ministry of Foreign Affairs of Japan, the Center -- and the MIT Energy Laboratory -- launched a number of inquiries, including a study of energy cooperation between the US and Japan by Professor Richard Lester, Department of Nuclear Engineering, and research on energy policy in Japan by Professor Richard 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.

Professors Michael Piore, Department of Economics, and Charles Sabel, STS, continued a comparative US-European study of the relationship between labor management relations and the general performance of the economy. They collaborated on a book on this topic, which will be published in 1982. The German Marshall Fund of the US supported this research.

Issues relating to development remain important parts of the Center's program. Professor Lance Taylor, Departments of Economics and of Nutrition and Food Science, completed a study

on factors affecting the prices of staple foods in developing countries and the effects, in turn, of the cost of such basic necessities on other aspects of economic development. This research drew upon different theories of economic development, work on international commodity trade, and stabilization and inflation. The work was conducted with Professor Graciela Chichilnisky, Department of Economics, Columbia University, with funding from the National Science Foundation. Professor Nazli Choucri, Department of Political Science, continued her work on migration among the Arab countries of the Middle East. Her work had 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 Pye, Department of Political Science, on the differing ways various Asian societies have responded to modernization of transportation, education, and communication.

The Center jointly sponsored, with the Center for Transportation Studies, a major international comparative study on the Future of the Automobile. Professor Alan Altshuler, Department of Political Science, has been 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, has addressed 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 have been funded by the German Marshall Fund; other support has been provided by the Lilly Endowment, the US Departments of Transportation and Energy, and by the national governments for their own teams.

Work progressed during the year toward creation of the MIT-Japan Science and Technology Program. Professor Samuels, in collaboration with Professor Skolnikoff, developed plans for a series of activities -- faculty research; undergraduate internships in Japanese industrial, private, and government research laboratories; graduate student study; symposia; and translations -- aimed at increasing two-way communication between American and Japanese engineers and scientists. Also high on the Program's priorities was the development of an infrastructure of courses at MIT to prepare faculty and students to participate in these opportunities. Initial funding has been received from the AMF Foundation, International Business Machines, and the Provost's Office; and major fundraising has begun. In addition to Professors Samuels and Skolnikoff, professors who will be involved as the program unfolds include: Jonathan Allen, Department of Electrical Engineering and Computer Science and Director of the Research Laboratory of Electronics; Donald Blackmer, Head of the Department of Political Science; James Bruce, Department of Electrical Engineering and Computer Science and Director of the Industrial Liaison Program; Merton Flemings, Department of Materials Science and Engineering; Michael Joroff, Director of the Laboratory of Architecture and Planning; Koichi Masubuchi, Department of Meteorology and Physical Oceanography; Ithiel Pool, Department of Political Science; Peter Smith, School of Humanities and Social Science; and Gerald L. Wilson, Dean of the School of Engineering.

Also during the past year the Center launched two exploratory faculty seminars which were intended to assess whether communities of interest exist that could support future research proposals. One of these seminars brought together faculty from engineering, science, humanities, and social science to explore energy policy in Brazil, Venezuela, and Mexico. Professor Brian Smith of Political Science, Charles Blitzer of the Energy Laboratory, and Richard Lockwood of Nutrition and Food Science took the lead in this effort. The second initiative concerned issues relating to women and international development. Edith Ruina of the Center for International Studies undertook a survey of faculty views of activities that might increase the interest of the faculty in including such issues in their research and teaching. Both these efforts were supported from funds made available to the Center for program development by the Exxon Education Foundation, and in the latter instance by the Provost's Office.

As in the past, the Center continued to work with other parts of the Institute. Close contact also has been maintained with the Energy Laboratory, the Center for Transportation Studies, the Center for Policy Alternatives, the Technology Adaptation Program, and the Program in Science, Technology, and Society. Similarly, the Center has close working ties with Harvard's Center for Science and International Affairs, the Center for International Affairs, and the Center for West European Studies.

The Center continued to conduct an extensive series of seminars for the MIT community. These seminars were widely attended by faculty and students from throughout the campus and the wider community. The Center also continued to publish its monograph series, as well as to assist in the book and journal article publication of research results and policy analyses. The

Center also had, as in past years, visiting scholars working in fields relevant to Center research. Last year, scholars in residence for all or part of the year came from Israel, Germany, Turkey, the Woods Hole Oceanographic Institute, the University of Denver, the US Military Academy at West Point, the US Air Force, and the Charles Stark Draper Laboratory.

EUGENE B. SKOLNIKOFF

Center for Materials Research in Archaeology and Ethnology

The 1981-82 academic year was the fifth year of operation for the Center for Materials Research in Archaeology and Ethnology (CMRAE). Activities focused in three areas: graduate education of students from the six participating universities; doctoral research among students from both Center-affiliated and non-Center universities; establishment of a CMRAE Summer Institute, and the offering of the first month-long Summer Institute course.

The Center offered a full-year graduate subject, Materials in Ancient Societies: Stone, to 10 students from five of its member universities, making a total of 120 students -- graduate students and senior undergraduates -- who have enrolled in CMRAE subjects since the Center's founding. This year's offering was designed and taught by Barbara Luedtke, associate professor of Archaeology at the University of Massachusetts at Boston. Student research projects involved either laboratory analysis of lithic collections excavated by them (or provided by universities and museums in the New England area), or experiments aimed at testing the mechanical properties and wear characteristics of certain classes of rock used prehistorically in the manufacture of agricultural and woodworking tools.

During the course of the year, two graduate students, one from Boston University and one from the University of California at Santa Barbara, joined the Center to begin full-time research toward the doctoral degree. One student, supervised by Professor Heather Lechtman (MIT, Anthropology/Archaeology and Materials Science and Engineering), is studying the prehistoric development of copper metallurgy in west Mexico and its relation to Andean metallurgies; the other student, supervised by Professor Suzanne De Atley (MIT, Anthropology/Archaeology), is concerned with the ceramic materials fundamental to ironsmelting technologies in east Africa during the iron age. Both students carry out their laboratory analyses and experiments in the CMRAE Graduate Teaching Laboratory at MIT.

A special event for the Center was the establishment of its Summer Institute, which has been funded in part through grants from the office of the President of MIT and the office of Institute Professor Jerome B. Wiesner, and in part from individual sponsors outside MIT. The Summer Institute was conceived by the Center's director as a mechanism through which scholars at non-Center institutions could benefit from the highly specialized and often unavailable education in laboratory-analytical skills in which the Center is expert. The aim is to provide individuals across the nation in such professions as anthropology, archaeology, the histories of science and art, and the conservation of archaeological and art objects with intense exposure to the theory and laboratory methods of the materials science of ancient and art historical materials. The Summer Institute format consists of a one-month intensive lecture and laboratory subject organized around a specific class of materials. The first course, Materials in Ancient Societies: Metals, was offered during June 1982. Professor Lechtman, the instructor, was assisted by Christopher Craig, supervisor of the CMRAE Graduate Laboratory, in which all classes were held. Professor De Atley serves as the administrative director of the Summer Institute.

After extensive advertisement of the course, a CMRAE committee chose 15 participants from a large pool of applicants. Five were graduate students and 10 were professionals -- faculty or heads of museum conservation departments -- spanning the disciplines of archaeology, anthropology, art and archaeological conservation, and the history of science. Six universities and seven museums from across the nation were represented by the Summer Institute participants. The course was an outstanding success and reflects a national interest in and need for the kinds of training the Center uniquely provides. The 1983 Summer Institute will treat the analysis of faunal remains from archaeological contexts.

The Center initiated a series of annual proseminars, six informal presentations during each academic year, enabling CMRAE faculty and graduate students to report on research in progress. This year scholars from the University of Massachusetts, MIT, and three departments at Harvard University discussed ongoing Center-related research.

HEATHER LECHTMAN

Committee on the Visual Arts

The Committee on the Visual Arts (CVA) -- comprised of faculty, students, and administrators -- met eight times during the 1981-82 academic year. In recognizing its advisory responsibilities and in looking forward to its role as one of the chief users of the Arts and Media Technology Facility, a number of sessions were devoted to drafting a policy statement to facilitate planning for the future of the arts and of media technology at MIT.

Several meetings reviewed possible acquisitions (gifts and purchases) for the Permanent Collection. The Committee hoped to acquire a Richard Serra sculpture for the new Athletics Center, using matching funds from the National Endowment for the Arts, but the senior administration, reflecting on the current economic situation, decided it would not be prudent to proceed with such a major commission. It was agreed that all future major art acquisitions for outdoor sites would be discussed and reviewed by the Vice President for Operations.

The Committee voted to allocate all of the one-percent funds associated with the dormitory at 500 Memorial Drive to the acquisition of a sterling collection of contemporary works on paper.

Other issues discussed by the Committee included increasing the audience for sponsored programs and encouraging participation of alumni; distinguishing the CVA program from other campus organizations, including the MIT Museum; and developing criteria for acquiring outdoor sculpture given the paucity of appropriate outdoor sites.

Through both gift and purchase, eight drawings or paintings on paper, two sculptures (an outdoor relief series by Gary Wiley for the Division of Comparative Medicine and a large steel construction by Michael Steiner), 23 photographs (major portfolios by Peter Campus and Robert Mapplethorpe), and 15 prints were added to the Permanent Collection. Vera List further donated five major prints to the Student Loan Collection. Three major paintings, by John McNamara, James Rosenquist, and Gary Bower, a sculpture by Richard Artschwager, and three photographs by Harold E. Edgerton and one by Ansel Adams were placed on extended loan by various lenders.

A sculpture by George Sugarman, *Improvisation on the Winds*, was loaned to the Joslyn Art Museum for a major traveling retrospective exhibition.

During this second year of a conservation program, the sculptures by Tony Smith, Alexander Calder, and Louise Nevelson were repainted, and Isaac Witkin's *Angola* was steel brushed and coated. Preventive and restorative conservation treatments were undertaken for a series of photographs by Ansel Adams and prints by M.C. Escher, as well as several paintings.

With the support of the Insurance Administration Office, the first comprehensive appraisal and photo documentation of both the Permanent Collection and Student Loan Collections was completed.

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 Program

The List and Stratton Student Loan Program consists of 230 contemporary graphics for which over 1,100 students and 45 student groups vied for borrowing privileges.

The Artist-in-Residency Project

Paul Earls, a composer and Center for Advanced Visual Studies (CAVS) fellow, created a room-size laser installation for the Hayden Gallery, accompanied by a varied series of lectures and performances, including a lecture on holography, a demonstration of the LOGO music system, a performance with music and lasers by Nora Post, and a performance of *Labyrinth*, conducted by Otto Piene, director of CAVS, and Mr. Earls.

The Walking Tour and Gallery Talks

The long-awaited book *Art and Architecture at MIT: A Walking Tour of the Campus* was completed, updated with new photographs of the Permanent Collection and recent additions, and is currently in production at MIT's Design Services. It will be published and distributed in the fall of 1982.

Numerous talks and tours were prepared by the Committee staff for visiting professional groups and other visitors.

Volunteers and Interns

Volunteers and interns played an important role in the CVA office, particularly in the preparation of the "Intimate Architecture" exhibition and catalogue.

Video and Slide Resources

The CVA is awaiting a decision by the Institute for Museum Services on funding to produce a series of videotapes on artists who exhibit and/or are artists in residence at the Hayden Gallery; previous CVA videotapes continued to be screened by various organizations outside MIT.

Publications and Public Information

Various educational publications were produced and extensive explanatory wall texts were posted prominently for each exhibition. Three exhibition catalogues were produced and two others are currently in production. Catalogue sales doubled this year, thanks to reorganized and systematic international distribution.

CVA-sponsored activities were reviewed in both the general and art press in Boston and nationally. Additionally, the MIT Permanent Collection was discussed at length in S. Lane Faison's reissued guide to the art museums of Massachusetts.

Proposal Preparation and Outside Support

Exhibitions were supported by the MIT Council for the Arts and the National Endowment for the Arts as well as several organizations and individual benefactors.

Student Participation in Art Selection

The CVA actively encouraged MIT students to participate in the art selected for their environment. Student residents of 500 Memorial Drive participated in the acquisition of an important collection of contemporary works on paper through the building's One-Percent-for-Art allowance.

A CVA-sponsored contest for MIT fraternities, sororities, and dormitories enabled Student House to spend $2,000 on art work for their environment; after much investigation, the group selected a monotype by artist Michael Mazur.

EXHIBITION PROGRAM

The 1981-82 exhibition season continued to demonstrate the CVA's commitment to acquainting both the MIT community and the larger New England audience with advanced and innovative work in painting, sculpture, photography, architecture, and design by both local and nationally known artists.

With one exception, the 14 exhibitions in the Hayden Gallery and the adjacent Hayden Corridor Gallery were all conceived, organized, and installed by the CVA staff. They drew an audience well in excess of 25,000, a significant increase in the ongoing upward trend of the past several years. Each exhibition opened with a public preview; many of the participating artists attended.

1981-82 Schedule

Looking at Prints from Boston-area Galleries, Hayden Corridor Gallery, August 28-September 27, 1981.

List and Stratton Student Loan Collection, Hayden Gallery, August 28-September 27, 1981.

Body Language: Figurative Aspects of Recent Art, Hayden Gallery, Part 1: October 3-November 8; Part 2: November 21-December 24, 1981 (catalogue in preparation by guest curator Roberta Smith, a New York-based art critic).

Images of Physics: Photographs by Berenice Abbott, Hayden Corridor Gallery, October 2-November 15, 1981 (traveled to California Institute of Technology in Pasadena and the Hudson River Museum in Yonkers).

Local Visions: The Urban Environs, Hayden Corridor Gallery, November 21, 1981-January 3, 1982.

Modulations: An Installation of Lasers and Music in Space, Hayden Gallery, January 8-31, 1982.

Two Painters on Paper: Robin Bruch and Stephen Mueller, Hayden Corridor Gallery, January 6-February 7, 1982.

Constructed Color, Hayden Gallery, February 12-March 21, 1982 (catalogue in preparation).

Dadakin: Recent Works by Boston-Area Artists in the Spirit of Dada, Hayden Corridor Gallery, February 12-March 28, 1982 (compendium of artists' statements compiled).

Great Big Drawings, Hayden Gallery, April 2-May 2, 1982 (exhibition brochure).

Versailles: Two Visions, photographs by Bruno Requillart and Deborah Turbeville, Hayden Corridor Gallery, April 2-May 9, 1982.

Intimate Architecture: Contemporary Clothing Design, Hayden Gallery, May 14-June 27, 1982 (exhibition catalogue with photographs by Robert Mapplethorpe).

Clothing by Artists, Hayden Corridor Gallery, May 14-July 11, 1982.

BORIS MAGASANIK
KATHY HALBREICH

Division for Study and Research in Education

This was a stressful and difficult year for the Division for Study and Research in Education (DSRE), in which the faculty continued its teaching and research responsibilities while a review process of the DSRE was being conducted by the Office of the Provost. The review committee was appointed in the fall of 1981 by the Provost, Francis E. Low, and consisted of Professors Wilbur B. Davenport, Jr., Samuel Jay Keyser, Joel Moses, and Frank E. Perkins (chairman). The review was initiated by the Provost as part of a general review and evaluation by MIT's new administration of those special, interdisciplinary entities that report to the Provost's office. It consisted of a review of the documentary history of the DSRE, a meeting with the entire professional staff of the Division, and individual meetings with each DSRE faculty member, principal research staff member, and several former associates.

In its report submitted in March 1982, the review committee recommended that the DSRE be ended as an administrative entity at a date later determined to be December 31, 1982, and that several of the DSRE's projects be relocated in other departments and laboratories at MIT and encouraged to expand and to grow. The report recognized that the termination of the DSRE might be interpreted by many as a signal that MIT was no longer interested in research in education. The committee expressed the hope that MIT's continuing efforts in computers and education and in cognitive science would partially correct this perception. Because of the importance of the field of computers, and education in particular, and the existence of several relevant areas of strength at MIT, the committee expressed the hope that pressure for the creation of an entity having many of the DSRE's original objectives would, once again, develop at MIT.

Involving as it did many hours of discussion on the part of DSRE faculty, collectively and individually, the review process was a major factor in the lives of everyone in the Division this year, and, at this writing, a set of discussions are under way to make productive and congenial arrangements at MIT for the variety of DSRE projects. The significance to MIT and to the field of education research of the Division's creation, its nine-year existence, and its end, will emerge only gradually. We make no attempt in this report to assess the Division as one of a line of enterprises at MIT dedicated to education research -- beginning in 1960 with the Science Teaching Center directed by Professor Francis L. Friedman, succeeded by the Education Research Center directed by Professor Jerrold Zacharias, and then, in 1973, by the Division. Each had a different educational and research focus appropriate to its time. Collectively, they represent a significant policy statement on the part of MIT -- in that it not only provides education for its own students, but sees its focus as a university "polarized around science and technology" as including a concern for the nature and quality of the education available to others.

Our belief in the importance and intellectual vitality of the work conducted by the Division, in particular its emphasis on interdisciplinary investigations into a) the interaction between the learner's informal, intuitive knowledge and the formal knowledge of the classroom and b) the effects of both affect and social context on the learning process, only deepens our disappointment at the Division's end as a collective entity. We remain convinced that it is appropriate, even necessary, for MIT to be a visible and lively contributor to an informed national debate about the education of scientists, engineers, and others, and thus to the improvement of our understanding of effective teaching and learning processes more generally. We remain hopeful that a successor organization dedicated to these goals will emerge.

As noted at the outset of this report, faculty continued their normal teaching and research responsibilities throughout the past year. Four new subjects of instruction were offered.

Cognitive Processes, offered jointly with the Department of Psychology by Professors Mary C. Potter and Susan Carey provided an introduction to human information processing and learning.

Introduction to Microcomputers in Education, offered by Professor Judah L. Schwartz jointly with the Graduate School of Education at Harvard, presented a categorical framework for classifying educational uses of the computer, the application of the cognitive sciences to the design of games,

tutorials, and simulations, and other related topics. The Project Lab in Microcomputer Software Design, offered by Professor Schwartz, provided students with the opportunity to design, write, and debug microcomputer software for use in university-level physics and mathematics subjects.

Developing Musical Perception: Cognitive and Educational Implications, offered jointly with the Department of Music by Professor Jeanne Bamberger, investigated the underlying cognitive structures which inform and shape musical perception.

Altogether, 20 subjects were offered, with a total enrollment of 191, including 60 students from the Harvard Graduate School of Education, and 81 registered in jointly offered subjects through the cooperating departments. It is worthy of note that the new subjects offered by Professor Schwartz were designed and offered in collaboration with Harvard as part of an ongoing discussion between the two institutions about the sharing of resources for the teaching of computer- and technology-related issues to a cadre of students who will be teaching in, designing educational software for, or making purchasing decisions on behalf of, public elementary and secondary schools. The very heavy enrollment in these subjects attests to the attractiveness of such subjects within the education profession.

In addition to teaching its regular subjects, faculty in the DSRE have supervised the work of the five students currently enrolled in its doctoral program -- three jointly with the Department of Urban Studies and Planning, one with the Department of Mechanical Engineering, and one with the Department of Psychology. In February 1982, Robert F. Mohl received the Ph.D. in Education and Media Technology jointly with the Department of Architecture. His thesis topic was "Cognitive Space in the Interactive Movie Map: An Investigation of Spatial Learning in Virtual Environments."

The Division continued its weekly seminar series, open to the MIT community, at which 18 MIT and outside speakers addressed a wide variety of issues in psychology, cognition, physics, mathematics, and anthropology as they relate to education. About half the speakers were members of the MIT community, including Professor Louis Bucciarelli, Program in Science, Technology, and Society (STS); Professor Bamberger; Robert C. Hayden, director, Secondary Technical Education Project; Professor Carey; Professor Pearla Nesher, head, Math Education Division, Haifa University, and research associate, DSRE; Professor Andrea diSessa, DSRE; Professor Sharon Traweek, Program in Anthropology/Archaeology, and STS; Richard Leacock, chairman, Film/Video Section; and Professor Schwartz.

Distinguished guests provided the other half of the seminars: Professor Herbert Lin, Department of Physics, University of Washington; Peter Elbow, Center for Humanities, Wesleyan University; Professor Eleanor Duckworth, Harvard Graduate School of Education; Gerald Holton, Mallinckrodt Professor of Physics, Professor of the History of Science, Harvard University, and Visiting Professor, STS; Professor Patricia A. Davidson, Mathematics, University of Massachusetts at Boston, and researcher, Learning Disabilities Clinic, Children's Hospital Medical Center, Boston; Albert Rothenberg, director of research, Austin Riggs Center, Inc., Stockbridge, Massachusetts, and Clinical Professor of Psychology, Yale University; Professor David H. Feldman, Eliot-Pearson Department of Child Study, Tufts University; Professor Hermina Sinclair de Zwart, Psycholinguistics, University of Geneva; and Dedre Gentner, research scientist, Bolt, Beranek, and Newman, Inc.

Attendance at the luncheon seminars has been healthy, discussion lively, and an appreciation for the electicism of approach evident.

The DSRE Working Paper series, produced with support from the Ford Foundation and edited by Professor Barbara Scott Nelson, continued to provide an active forum for the work of DSRE faculty members and associates. Seven papers were issued during the past year, each with a circulation of 100-150. New titles included: Professor diSessa's two papers, "Unlearning Aristotelian Physics: A Study of Knowledge-based Learning," and "Phenomenology and the Evolution of Intuition"; Professor Bamberger's "Growing-up Prodigies: The Mid-life Crisis"; Professor Duckworth's "Understanding Children's Understanding"; Professor de Zwart's "Children's Ideas about Written Words and Written Numbers"; Professor Schwartz's "Computer Pictures for the Mind's Eye: A Cognitive Odyssey from Percept to Concept"; and Ana Quintero and Professor Schwartz's "The Development of the Concept of Ratio in Children."

The Division values its links with other MIT laboratories and centers, in particular its ties with the Center for Cognitive Science -- represented by the membership of Professors Daniel Osherson and Carey. Professor Schwartz continued his participation in the Concourse Program, and Professor Bamberger her involvement with the Music section of the Humanities Department.

Professors diSessa and Harold Abelson continued their work with the Laboratory for Computer Science where, with support from the Advanced Research Projects Agency of the Department of Defense, they are developing "Boxer," a computer language which will serve as the basis of an integrated computational environment for novice users.

Active collaborations with other colleges and universities were forwarded by the involvement of Professor Schwartz with the Harvard Graduate School of Education, where he served as a member of a working group on interactive technology and education; and by Professors diSessa, Bamberger, and Schwartz who developed a significant interchange with the Bank Street College in New York.

Members of the DSRE faculty continued in their advising capacities to a number of national and international educational forums. Professor Schwartz continues to act as a consultant to the French Government in the establishment of a new French National Science Museum, La Musee Nationale de Science et Industrie; Professor Nelson continued as a member of the study group on the National Institute of Education's (NIE) Research Program on Post-secondary Education. Professor Margaret L.A. MacVicar was named a member of the advisory board of the North Carolina School of Science and Mathematics and a trustee of the Boston Museum of Science. Professor Bamberger remains active on the Social Science Research Council, in particular as a member of the newly formed Committee on Development, Giftedness, and the Learning Process. She also serves as a consultant to the Science and Math Curriculum Development Group of the University of Tel Aviv.

Research Program

The DSRE's research volume continued at its stable level of about $500,000 per year, with support coming from the National Institute of Education (NIE), the National Science Foundation (NSF), the Spencer Foundation, and the Ford Foundation. The long-term research interests of members of the DSRE faculty were pursued through a variety of continuing research programs and the initiation of several new research projects.

Professor Bamberger was awarded a continuation of her grant from NIE to further analyze the data which resulted from the two-year, NIE-supported, Project in Teacher Development, which she conducted with her associate, Professor Duckworth of Harvard University. In the data analysis, Professor Bamberger's group is focusing on the interpersonal relations among the teachers and those between project staff and teachers as they participated in the workshop sessions. They are also analyzing the conceptual development of the teachers with regard to specific intellectual issues that engaged them over some time: time-space-motion, long division, and understanding of the moon's behavior.

Professor Bamberger's preliminary work on the cognitive/affective development of musically prodigious children led her this year to hypothesize the existence of a "mid-life" crisis occurring in the mid-teens of the musically prodigious -- a crisis in which she suggests that "figural" and "formal" ways of comprehending music must be reconciled and integrated if mature artistry is to be attained. This preliminary work is reported in her working paper, "Growing-up Prodigies: The Mid-life Crisis." This work has attracted sufficient attention to provide the basis for a conference on the mid-life crisis among musicians and scientists to be convened at MIT in the fall of 1982, and to have been awarded a grant from the Spencer Foundation for the preparation of several case studies of musically prodigious children.

Professor Bamberger is also in the process of developing a new text on music which would integrate the kind of activities presented in her earlier book with Brofsky, *The Art of Listening*, with active musical experiments using LOGO music. The long-term enterprise entails the development of the LOGO computer music system and associated curriculum for teaching musical perception.

Professor diSessa was awarded a grant from the Spencer Foundation to further develop his research into the role of intuition as a class of knowledge in learning introductory college physics -- particularly to augment the database on which the study rests -- and to improve, elaborate, and expand the set of probe problems beyond those on the fundamentals of motion to include the content area of electricity. He is also exploring an additional class of knowledge, that of "intuitive epistemology," i.e., what students seem to think is the nature of knowledge, how that affects how they go about learning, and consequently, what they learn. This work has produced a pair of case studies which show contrasting preoccupation with "equations and results" for one

student and "understanding what's going on" for another. Professor diSessa finds that the equation-oriented student's commitment to his or her view, concerning what knowing physics is like, is extremely robust in a way typical of intuitive belief systems. Professor diSessa's work on understanding how college students think about physics provides a base for his work with Professor Abelson in offering an undergraduate seminar on "Computation as a Framework for Exploring Physics and Math." With an enrollment of 13, the seminar provides a context for the further development and evaluation of educational materials which derive their pedagogical thrust from diSessa's study of intuition, and have the pedagogical agenda of building a better intuitive grasp of the physics and a better sense for the enterprise of modeling the world, as opposed to concentrating on facts and even laws.

Professor Benson R. Snyder was awarded a major, two-year grant from the Ford Foundation to continue the longitudinal study of MIT's Class of 1965, and to supplement that study with data on the MIT Class of 1975, which includes a higher proportion of minorities and women than did the Class of 1965. The study explores the long-term effects of MIT's "hidden curriculum" and the adult and career development of scientists and engineers. Of particular interest are a) the ways in which the student's sense of self became linked during their undergraduate years to their increasing mastery of a subject domain in the Institute's particular and pressured learning culture; b) how the acquisition of technical and problem-solving skills opens up for the adult the possibility of solving (or reformulating) a wide range of scientific and engineering problems; and c) how the constant use of particular cognitive skills, in turn, has an effect on the individual's sense of worth and self esteem, and thus on his or her patterns of coping and adaptation in adult life. The research group includes Dr. Lora Heims Tessman of the MIT Medical Department, Professor Kenneth Keniston, Professor Kenneth Manning, and Dr. Evelyn Keller, all of STS. Salient themes which have emerged during the early stage of analysis of interviews from the Class of 1965 include how students deal with time, pressure, and overload and variations in cognitive style. Several MIT officials, whose offices both serve and collect data about students and alumni, have been helpful in identifying sources of data for the study: Warren Wells, registrar; Robert Weatherall, director, Career Planning and Placement; and William K. Hecht, executive vice president, Alumni Association.

Professor Schwartz completed his work in collaboration with Dr. Nesher on an NSF-supported study of children's internal representation of numbers and quantifiers and with Professor Ana Helvia Quintero, Mathematics, University of Puerto Rico, on the development of the concept of ratio in children. The former study analyzed the theories of the two dominant schools of thought on the development of number, the Piagetian and the "American" (Gelman et al); observed that both schools portray only a partial picture of the child's development of quantification; and hypothesized that there are several modes of quantification which develop in parallel, but not necessarily in synchrony. In order to reach the point of being able to model mathematically, they hypothesize, it is necessary (but not sufficient) for children to coordinate and synthesize the various modes of quantification. This competence develops with the emergence of symbolic function, i.e., with the development of the capacity to reference. Studies in early language acquisition, linguistic studies on universals, and experimental studies of quantifiers were examined for evidence supporting this hypothesis. The Schwartz/Quintero study explored the relationship between children's use of qualitative and quantitative models of ratio, showing that children originally deal with ratio problems qualitatively and only later develop quantitative models and that they deal differently with discrete and continuous quantities.

Professor Seymour A. Papert was on leave from the Institute during the year to develop the Centre Mondial, Informatique et Resource Humaine, under the auspices of the French Government. In collaboration with Jean-Jacques Sevrin-Schreiber, who proposes that in their development the Third World countries "short circuit" the industrial structures of the advanced nations and move directly into an information structure, and under the directorship of Professor Nicholas Negroponte, Architecture, the Centre Mondial was established in Paris during the spring, with a research and development program aimed at integrating three perspectives. These are: technology (computers and video discs), social sciences, and intervention strategies.

Professor MacVicar, Cecil and Ida Green Professor of Education, has continued work on a book describing the Undergraduate Research Opportunities Program (UROP). In her report on the year's activities she notes that her emphasis has evolved from an historical accounting of <u>how</u> UROP evolved into an interpretive account of <u>why</u> it has the objectives, attitudes, policies, style, personality, achievements, and failures <u>that</u> it does. "UROP is like a mathematical 'map' of MIT itself. The Program is as it is, because MIT is as <u>it</u> is. . . . One must listen <u>very</u> hard

to the voices in an institution: the whispers as well as the howls, the old words as well as the recent, and from these discern the program shape or curriculum flavor to achieve some end."

In addition to continued work on her book, Professor MacVicar has turned major energies to the problems of technological illiteracy of the non-scientist public and, relatedly, to science and mathematics education in schools. She has addressed a number of national and international audiences on these issues, as well as attending the National Academy of Sciences and the National Academy of Engineering Convocation on Precollegiate Science and Mathematics Education.

Professor Nelson began preliminary work on a study of implementor's "accounts" -- the "accounts" of a situation which an actor makes in order to develop an effective program of action. In particular, her interest centers on the implementation of educational innovations. The first implementors to be studied are involved in developing ways in which liberal arts colleges can integrate computation into their academic programs.

Dr. Sylvia Weir's work on further developing LOGO teaching materials for use by the physically handicapped and the learning disabled proceeded with support from the NSF, the US Department of Education's Office of Special Education, and the Hyams Trust. The grant from the NSF supported work to increase the accessibility of science education and scientific careers to the physically handicapped by using the LOGO system to develop curriculum materials in computer programming, mathematics, and physics. Undertaken at the Cotting School in Boston, computer programming is now available to all senior school students and has been extended to students in grades 1-4 in the domains of mathematics and science. Senior school students have been exposed to electronics and LOGO, Newtonian dynamics on LOGO, and the conversion of some regular school mathematics into the LOGO system.

The grant from the US Department of Education supported work, also with the Cotting School, to develop videotaped teacher support materials to enable school systems remote from the LOGO Lab to install and manage a LOGO-based computer center and to integrate LOGO activities into the school curriculum. The first three video modules will be ready for evaluation in August.

The grant from the Hyams Trust supported the development of LOGO materials for use with autistic children through a project conducted jointly with the League School for Autistic Children. The project has addressed itself to several questions of feasibility. The School has been sufficiently impressed with the pilot LOGO work to commit resources to ensure its continuation and to have the teachers continue their LOGO training over the summer. The Hyams grant also supported dissemination activities in the form of lecture/demonstrations at several teacher centers: Acton, Cambridge, North Oxford, MA, and Portland, ME. The response has been enthusiastic.

As we conclude this report, we wish to take note of the special support given the Division by a number of associates and friends. Professor William T. Martin, the Division's first director, played a critical role in its design, and has served as an informal and highly valued advisor in the years since his retirement. Cecil and Ida Green have also been exceedingly generous to the Division over the years in their funding of the Cecil and Ida Green Professorship, (held by Professor Papert for five years and currently held by Professor MacVicar), two Cecil and Ida Green Career Development Chairs, and in their provision of a development fund which was crucial during the Division's early years. As is so well known to all at MIT, their enthusiasm, vision, and finely tuned sense of what it takes to make an academic enterprise work make them unique friends, indeed. J. Erik Jonsson has been particularly supportive in his vision of a link between MIT and Texas Instruments, which would center on the educational use of computers in the development of a LOGO program at the Lamplighter School in Dallas, TX. His insistence that this was an important vision, and his persistence in realizing it stand as examples of the high level of educational leadership which many at MIT have come to associate with him.

Several private foundations provided important and continuing support to the Division over the years, and we wish here to recognize those contributions. The Lilly Endowment supported the development of the Lilly Teaching Fellows Program. The Ford Foundation provided a substantial and highly flexible development fund which enabled the Division to supplement other, more restricted funds in order to bring distinguished visitors to MIT, support summer work, establish a working paper series, and undertake the numerous other activities which, collectively, contributed to building a rich and articulated academic community.

When the Division was created in 1973, it was done with the conviction that the time was ripe for a new style of education research and that MIT was the best place for this to happen. Not

only was the Division created as a deliberate intellectual departure from MIT (albeit one which would draw on the Institute's strengths), but it was created also as an administrative innovation --to combine the best features of an interdisciplinary laboratory and an academic department. It has been determined that this administrative invention is inappropriate, and MIT will seek other forms of organizational support for its interests in education. However, the development of an academic community is accomplished primarily through the intellectual growth and development of its members, the recognition of the intellectual usefulness of their findings and methods, and the development of a younger generation of faculty and students through whom the work will be further advanced. These criteria for success may be aided or hindered by particular organizational forms, but stand independently of them. It seems clear to us that many of these goals for the Division have been met. The work of members of the DSRE faculty and research staff has matured and, by virtue of close colleagueship, developed in directions which make, collectively, a unique contribution to our understanding of teaching and learning processes. In this respect, we count the years invested in the establishment of the Division to have been a success, and believe that all who have been a part of it should take pride in that association.

Personnel

Honors and awards were received by DSRE faculty as follows: Professor Carey was elected president of the Society for Philosophy and Psychology.

Professor Papert was on leave for research purposes during the past year.

The Division welcomed the following as long-term visitors: Daniel Breton, professeur agregé de Sciences Naturelles, Lycee de Noisy le Sec., Paris, as a visiting lecturer in DSRE; Professor Nesher, as a visiting associate professor in DSRE; and Professor John Richards, Department of Philosophy, University of Georgia, as a visiting assistant professor in DSRE.

Visitors whose terms were of shorter duration were: Dr. Alex Blanchet, Maitre-assistant du Professor B. Inhelder, Université de Geneve, Faculté de Psychologie et des Sciences de l'éducation as a visiting lecturer, DSRE; Dr. Harry Judge, director, Department of Educational Studies, Oxford University, as a visiting professor in DSRE; Professor Edwina Rissland, Computer Science, University of Massachusetts at Amherst, as a visiting assistant professor in DSRE; and Professor Hermina Sinclair de Zwart, Psycholinguistics, University of Geneva, as a visiting professor of Education and Developmental Psychology in DSRE.

We note with a sense of deep sadness and loss the death in January of Professor Roy Kaplow. Professor Kaplow was a strong supporter and colleague who was active in the early development of the Lilly Fellows Program and in the development of an interactive computer facility in use at the Cambridge Public Library. He is much missed.

Both the director and the associate director wish to formally express special appreciation for the contributions of the DSRE support staff during the past year. Debra Banerjee, Nancy Cavanagh, Ligia Domingo, and Diane Watson-Mitchell have unfailingly provided cheerful and professional service. Our special thanks go to Marion Wasserman, administrative officer, who supervised that staff and provided extraordinary support to all members of the Division.

BENSON R. SNYDER
BARBARA SCOTT NELSON

Educational Video Resources

Educational Video Resources (EVR) continues to provide facilities, equipment, service, and advice to the MIT community on the educational, creative, scholarly, and research uses of video. We are a primary source of information to the community on developments in telecommunications and their implications for the various activities of the Institute. In addition, we are gradually taking on the roles of a production consulting service, producer, and promoter of MIT-related videotapes.

Institute clients include all academic departments, research laboratories, and the MIT administration. We continue to be the primary production facility for short video courses on technical topics marketed worldwide by the Center for Advanced Engineering Studies. The EVR Equipment Library serves many individuals and groups, including students in classes at the Film/Video Section, and Fellows at the Center for Advanced Visual Studies. The most time-consuming part of production is often the editing process, and our editing facilities continue to be busy, often operating around the clock. The cable system carries the video output of members of the community, as well as outside sources, and permits live and interactive educational and cultural events. During the year, the cable system has been extended into some of the new and renovated structures at both ends of the campus.

Supporting projects by members of the community. The unpublished archive submitted with this report contains descriptions of 315 projects for which we provided consultation, assistance, and equipment during the year. The major functions of our staff are receiving, consulting, budgeting, approving, assigning facilities, monitoring progress, and encouraging completion of these projects by MIT students, staff, and faculty. Some examples of such projects include the following:

- production of instructional tapes on computer use in mathematics, physics, language arts, and computer programming for teachers of elementary and secondary school students, especially those with physical handicaps.
- videotaping varsity diving team practice for immediate critique.
- a senior thesis in physics, producing a videotape on a varied group of nuclear-freeze activists.
- assistance and facilities for the production of a series of tapes on brain dissection with a world expert in the Department of Psychology.

Carrying out productions ourselves. Increasingly, we are being approached by individuals and organizations at the Institute to produce videotapes for a variety of purposes including education, documentation, publicizing research, and reporting to funding agencies. Examples include:

- a documentary entitled *Evaluating the Properties of Offshore Soils* for the Department of Civil Engineering and the MIT Sea Grant Program.
- a record of the summer course, Nuclear Power Plant Safety, given by the Department of Mechanical Engineering.
- a promotional tape for the Community Service Fund.
- a tape on *MIT: Twenty-five Years Later* for the Class of 1957, used primarily to raise money for the class gift.
- documentation of special events: visits by Vice President Bush, Billy Graham, and Ralph Nader; retirement symposium for Dean William Porter; Veteran's Day Symposium, "How to Prevent Nuclear War"; and Culture and Technology Seminar.

- a six-minute tape on artificial skin that might be a pilot for a series on MIT research projects for professionals as well as for the general public.

We have an intern program that draws on students from nearby colleges. Half a dozen interns have helped us with some of these productions while learning the ropes themselves and producing a weekly program for the cable system entitled *MIT in Motion*.

The cost of quality cameras and editing equipment has been decreasing steadily in spite of inflation, and a variety of distribution networks are springing up for whichever industrial 3/4-inch videotapes have satisfactory technical quality. These developments encourage a vision of an integrated production and distribution effort that provides the MIT community with a variety of production services and openings to a range of audiences (both inside and outside the Institute) for the resulting videotapes. The Communications Consortium, an independent consortium of 32 educational and cultural organizations housed at MIT, is investigating distribution channels for its members' programs that may supplement our own effort.

Increased educational uses of video. An Advisory Committee has been meeting to evaluate our program and to make recommendations to the Provost for the future. Members of this committee have encouraged our movement toward production and distribution. In addition, they propose an increased role in the large-enrollment courses, such as using the MIT Cable System to provide interactive (but anonymous) tutoring help of difficult concepts, current problem sets, and upcoming examinations. Lectures may also be recorded and replayed as needed with supplementary films and tapes carried on the system.

Looking ahead: the loom of communications. It is difficult to predict the outcomes of the many present technical and social developments surrounding telecommunications. We feel that the effects on the higher education community will be gradual and spotty in the short term, but profound in the long term. We look to a unification and coordination of the programs of various groups that promote education and culture across the spectra of age, level of education, mode of funding, and geographical location. MIT, with its rich combination of programs in education, research, and the arts, is in a unique position to contribute to, and take advantage of, these developments.

EDWIN F. TAYLOR

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 the Chairman of the Corporation; Mary Morrissey, director of the Information Center; Gayle M. Fitzgerald, assistant for special events; Winston E. Flynn, assistant registrar; and Steven Thomas and Kenneth Dumas of the Student Center Committee. This committee meets weekly to review facilities use requests.

Although use of MIT facilities is in part governed by the Institute's tax-exempt status, 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 committee are drawn into broader issues involving controversial and difficult potential use 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 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 1981-82, in addition to a number of smaller meetings, the Institute was host to, among others: the Northeast American Society for Eighteenth Century Studies Conference; the CAD/CAM Technology in Mechanical Engineering Conference; the Thirteenth Annual Power Electronics Specialists Conference; the American Humanist Association Conference; the First National Conference on Issues Facing Black Administrators at Predominantly White Colleges and Universities; and the Fourth International Conference on Resource-Conserving, Environmentally Sound Agricultural Alternatives. 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

EDUCATIONAL PROGRAMS

The Biomedical Sciences Curriculum

The Health Sciences and Technology (HST) Division continues to be proud of the accomplishments of its students. Although HST students constitute only 15 percent of the Harvard Medical School student body, they represent a majority of M.D./Ph.D. candidates. HST students received 60 percent of honors in a special field and four out of 11 special prizes and awards given on graduation in June 1982. They continue to receive outstanding appointments as interns and residents in excellent teaching hospitals.

The Curriculum Committee, chaired by Professors Walter H. Abelmann and Herman Eisen, reviewed several HST courses in depth. Special attention was given to the neurosciences in an effort to achieve better integration of the pathophysiology of disorders of the nervous system with basic neuroanatomy and neurophysiology.

In the light of changes in the regular preclinical and clinical curriculum of the Harvard Medical School, the HST Curriculum Committee has prepared a plan to enhance opportunities for HST students, to include a new course in genetics, and greater access to a revised course in pharmacology. The Curriculum Committee reemphasized the importance of the concentration and thesis requirements and the maintenance of curricular flexibility.

A new feature introduced this year was a research seminar presented twice monthly by HST students. The purpose of these seminars was to improve communication and communication skills among students and to act as a forum for discussion. The caliber of the seminars was very high. The attendance, however, was modest. A more suitable time and place for the seminars will be sought in an effort to improve attendance.

Medical Engineering and Medical Physics Curriculum

During the academic year 1981-82, the Division continued to expand its program in Medical Engineering and Medical Physics. Ten new students joined the doctoral program in this field, which raises the total number of students to 38. Six students entered the clinical year and one student, Anthony Patriarco, completed the program for the Ph.D. in the Department of Physics at Harvard University.

For the spring term, HST-201 Introduction to Clinical Medicine and Medical Engineering was offered at the Norwood Hospital for the first time, under the direction of Dr. John Cadigan. Because the teaching program at the Norwood Hospital is small even though the facilities are comparable to those at one of the larger hospitals in the Boston area, Dr. Cadigan was able to provide personalized instruction to the Medical Engineering/Medical Physics students.

Three new subjects in Medical Engineering/Medical Physics were developed this year. One subject, HST-210 Innovation and Conceptual Design for the Solution of Technical Problems in Clinical Medicine, developed by Dr. James Weaver and Professor Alan Nelson, attempts to educate medical engineers and medical physicists in the methodologies of innovation in the clinical setting. The second subject, HST-582 Biomedical Signal Processing, developed by Professors Dan Adam and Robert Kenyon, presents the mathematical formalism for the analysis of signals of biological origin and applies them to various health care situations. The third subject, HST-545J Fields, Forces and Flows: Background for Physiology II, developed by Dr. Raphael Lee and Professor Alan Grodzinsky, extends the theory of the behavior of biomaterials under the application of electric fields and introduces the clinical perspective.

Dr. Weaver has revised HST-580 Medical Engineering Measurements, to incorporate more material on biochemical measurements in the clinical setting, and Dr. Edwin Trautman has revised companion subject HST-581 Medical Engineering Measurements Laboratory, to provide students with more opportunities for hands-on experience in making such measurements in physiological situations.

A new department of biomedical engineering was developed at the Massachusetts General Hospital. This department will have the full range of teaching, research, and clinical responsibilities, and will play a central role in the education of medical engineers and medical physicists. It is expected that this department will be under the direction of the Edwin Hood Taplin Professor of Biomedical Engineering in the Harvard-MIT Division. This endowed professorship in Medical Engineering and Medical Physics was made available to the Division through the generosity of John Taplin, Class of 1935. By establishing the professorship in this manner, it will be possible to establish for the first time in the field of biomedical engineering a direct formal link between a department in a university medical school teaching hospital and a school of engineering.

In the further development of the Medical Engineering and Medical Physics Program, we have been helped by the establishment of another endowed professorship. This professorship, the J.W. Kieckhefer Career Development Professorship in Technological Assessment in Health Care, has been made possible by a grant from the J.W. Kieckhefer Foundation for the purpose of teaching and research on the technical, economic, social, ethical, and political dimensions of new technologies in health care.

Radiological Sciences Program

During the 1981-82 academic year, the Harvard-MIT Division of Health Sciences and Technology, together with the MIT Graduate School, Harvard Graduate School of Arts and Sciences, and the Harvard School of Public Health, has been planning a new doctoral program in the Radiological Sciences. The program will be administered by the Division. It will encompass radiation therapy, diagnostic imaging technology, and radiation biophysics, and will be concerned with ionizing radiation, ultrasound, laser technology, and nuclear magnetic resonance. The Program is designed for students in engineering, physics, and the allied sciences. During the first two years of the Program, students will complete all requirements for the S.M. degree in one of these fields in addition to the subject requirements specific to this Program. After successfully completing the doctoral qualifying examinations, students will then engage in research which concludes with a thesis defense. The Program is to be supported in part by a grant from the National Cancer Institute. Professor Gordon Brownell will be program director. Professors Bengt Bjarngard and Nelson are to serve as co-directors.

Health Physics

In response to a perceived need for health physicists in the nuclear industry, the Harvard-MIT Division of Health Sciences and Technology has joined with the MIT Department of Nuclear Engineering and the Harvard School of Public Health in formulating a two-year curriculum which may lead to a master's degree in health physics for graduate students in nuclear engineering. This Program is designed to educate individuals, with undergraduate degrees in the physical sciences or nuclear engineering, to a high level of academic excellence in the principles of radiobiology, radiation dosimetry, isotope preparation and handling, risk assessment, and practical reactor operation and instrumentation. The Program draws on the academic resources of the Harvard School of Public Health, the MIT Department of Nuclear Engineering, and the Harvard Medical School. Graduates of the Program should find employment as health physics professionals in academic/medical institutions, government agencies, and private industry.

FACULTY

Dr. Farish A. Jenkins, Jr., professor of Biology, Harvard University, was appointed as professor of Anatomy in the Harvard-MIT Division, reflecting his distinguished contributions to the Division. He has taught in HST-010 Functional Anatomy of Man since 1976 and has ably directed the course since 1978. Dr. Lee Gehrke was appointed lecturer in the Harvard-MIT Division for the academic year 1982-83 and assistant professor of Anatomy jointly with the Department of Anatomy at Harvard Medical School starting in June 1983. Dr. Gehrke also will have major teaching responsibilities in HST-010 Functional Anatomy of Man.

Dr. Allan S. Detsky, HST and MIT Class of 1978, assistant professor of Health Economics in the Faculty of Medicine, University of Toronto, was appointed visiting assistant professor in the Harvard-MIT Division. Professor Detsky has taught HST-900 Topics in the Economics of Health Care for the past several years.

Dr. Robert Langer, associate professor in the Department of Nutrition and Food Science, was also appointed associate professor in the Harvard-MIT Division of Health Sciences and Technology. Professor Langer has participated in HST-110 Renal Pathophysiology, and will be contributing to the educational and research activities of the Medical Engineering and Medical Physics curriculum.

HST RESEARCH ACTIVITIES

Research and development activities in HST engage multidisciplinary groups of scientists, engineers, and physicians, and span projects applying engineering and the natural sciences to the solution of important medical and health problems. Sixty research and development projects are currently in progress and comprise three major centers and four broad programs, as well 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 interdisciplinary research involving engineering science and development of new clinical instrumentation. Projects currently under way include cardiac arrhythmia analysis with a patient-carried computer; measurement of the thermal properties of tissue; integrated electrode and signal processing arrays for recording from mammalian nerves and *in vitro* heart cell cultures; beat-to-beat and breath-to-breath fluctuations in cardiovascular and respiratory function; new methods for rapid microbial culture; and non-invasive blood gas measurements. Four projects involve industrial collaboration in an effort to facilitate technology transfer.

The Harvard-MIT Rehabilitation Engineering Center is a collaborative effort of MIT and Harvard Medical School, and has its clinical facility at Children's Hospital Medical Center. The Rehabilitation Engineering Center applies engineering science and technology to the problems of the physically handicapped. The director of the Center is William Berenberg, M.D., and the associate director for engineering is Robert W. Mann, Sc.D. The core area of research is the measurement of human performance through instrumentation for purposes of rehabilitation, and focuses on human neuro-muscular-skeletal movement disabilities. The clinical and the engineering staffs collaborate to identify and quantitate the pathologic conditions, devise restorative and therapeutic processes, evaluate the potential for rehabilitation, and disseminate the results to rehabilitation engineers and relevant medical practitioners.

The Center for Health Effects of Fossil Fuels Utilization is devoted to the study of potential health effects of combustion products of fossil fuels. Key objectives of the research directed by Professors Gerald N. Wogan, John P. Longwell, William G. Thilly, and Klaus Biemann, have been to characterize the products of various combustion sources, develop a database with which to assess potentially mutagenic and/or carcinogenic products, and identify alternative combustion methods and fuel utilization strategies that could reduce health hazards. To accomplish these

goals, a broad program of closely integrated research efforts involving combustion engineers, analytical chemists, and toxicologists has been undertaken.

Broad Research Programs

The objective of the Program on Optimization of Dose Distribution in Cancer Radiation Therapy, under the direction of Dr. Bjarngard, is to develop methods for external beam radiation therapy which will increase the dose to the tumor and/or will decrease radiation-induced complications in normal tissues. Computer-based treatment planning procedures have been developed which utilize a computer-controlled linear accelerator and which afford versatile beam configuration and shaping. The clinical application of these techniques is being developed and expanded.

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

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 Brownell, are improvements in clinical nuclear medicine through the design and development of radiopharmaceuticals that can lead to greater specificity, reduced dosage, and enhanced diagnostic imaging quality.

Individual projects include 1) the development of new methods to characterize reactive species in radiopharmaceuticals using high-pressure liquid chromatography and field desorption mass spectrometry; 2) a study of diesel exhaust effects in railroad workers; 3) the development of a radioactivity detection system to screen patients for coronary artery disease; 4) determination of the mechanisms by which double-stranded RNA regulates protein synthesis; and 5) elucidation of the mechanisms controlling the synthesis of hemoglobin and other proteins in animal cells.

New Research Projects

A new research program in Tumor Hyperthermia: Science, Technology, and Evaluation, under the direction of Professor Padmakar P. Lele, has been established within HST and the Department of Mechanical Engineering. Drs. H. Frederick Bowman and Emil Frei III serve as co-principal investigators. The program project grant of 11 projects represents a multidisciplinary effort for further evaluation and refinement of hyperthermia as a modality in cancer therapy. Phase I and Phase II trials will be continued in patients with superficial and deep tumors, using hyperthermia alone, or in conjunction with radiation and drugs. A technique for the production of such hyperthermia with sparing of normal tissues has been developed utilizing steered, focused ultrasound, and has been evaluated in experimental animals and human patients. The program involves nine local institutions and seven MIT departments.

A second new research program entitled Phase I Evaluation of Equipment for Hyperthermic Treatment of Cancer is directed by Professor Lele. The essential objective of this work is to determine whether the various hyperthermia systems currently being used in clinical trials of local hyperthermia can produce therapeutic levels of temperature distribution in deep tumors located in different anatomical regions in humans, without placing the surrounding vital, normal tissues at an unacceptably high risk. This work is being carried out in conjunction with Harvard Medical School faculty members at the New England Deaconess Hospital.

Several other new research projects were initiated during the past academic year. They include studies on Thermal Dosimetry and Blood Flow Measurements for Hyperthermia; Molecular Basis of Globin Gene Expression; Stress-Morphology Relations for Trabecular Bone *in vivo*; Mechanics of Normal, Arthritic, and Prosthetic Knees; and Neural Prostheses.

IRVING M. LONDON

Whitaker College of Health Sciences, Technology, and Management

MIT celebrated the dedication of the building complex for Whitaker College and the Medical Department Health Services Center on March 4 and 5, 1982. The dedication was preceded by a scientific symposium devoted to principal programmatic themes in the health sciences, technology, and management. The speakers and their subjects were Michael S. Brown, Paul J. Thomas Professor of Genetics, University of Texas Southwestern Medical School, on "Lipoprotein Receptors: Genetic Defense Against Atherosclerosis"; Susumu Tonegawa, Professor of Immunology and Cell Biology, MIT, on "Somatic Generation of Immunoglobulin Genes"; Walter A. Rosenblith, Institute Professor, MIT, on "From Frog and Electric Fish to CAT, PET, and NMR"; David H. Hubel, George Packer Berry Professor of Neurobiology, Harvard Medical School, on "Architecture of Primary Visual Cortex in Macaque Monkeys"; Alain C. Enthoven, Marriner S. Eccles Professor of Public and Private Management, Stanford University Graduate School of Business and Professor of Health Care Economics, Stanford University School of Medicine, on "Using Market Forces to Control Health Care Costs"; Edward B. Roberts (panel chairman), David Sarnoff Professor of Management of Technology, MIT; Lawrence D. Brown, research associate, Brookings Institution; Richard J. Greene, director, Medical Research Service, Veterans Administration; Paul L. Joskow, Professor of Economics, MIT; Harvey M. Sapolsky, Professor of Public Policy and Organization, MIT; Paul Starr, Assistant Professor of Sociology, Harvard University on "The Health Care System in the 1980s."

A reception and dinner were held in March to honor Mrs. Helen F. Whitaker and other principal donors who made the construction of this building possible. At this dinner President Donald Kennedy of Stanford University delivered an address.

At the dedication ceremony Chairman Howard W. Johnson; President Paul E. Gray; Mrs. Whitaker; Frederick C. Robbins, President of the Institute of Medicine of the National Academy of Sciences; Dr. Irving M. London; and Dr. Melvin Rodman delivered short addresses. Subsequently, there was a reception in the atrium of the new buildings at which the portraits of Uncas and Helen Whitaker were unveiled, and the Albert O. Seeler Reading Room, and the Irwin W. Sizer, and George W. Thorn Seminar rooms were dedicated. In addition, the auditorium and lounge which were presented by AMP, Inc. were also dedicated.

Administrative Organization and Structure

After extensive consultation with a faculty committee and with the Academic Council, the MIT administration proposed an administrative organization and structure for the Whitaker College. The structure was presented for discussion and consideration by the Visiting Committee at the first meeting of that Committee held on December 5, 1981. This plan has also been presented to various faculty groups and to 18 MIT alumni clubs in the United States and Canada.

Division of Biophysics and Biomedical Engineering

This Division is focused on four major areas at the present time: pharmacokinetics and drug delivery systems, imaging systems, cardiovascular and respiratory physiology, and cryobiology. In connection with this work, Professor Robert S. Langer joined the faculty of the College and moved his laboratory to Building E25. Professor Langer, who holds a joint appointment in the Department of Nutrition and Food Science, will assume primary responsibility for the pharmacology effort in the College. This activity, which includes both teaching and research, involves faculty and students from the Departments of Chemistry, Chemical Engineering, and Nutrition and Food Science.

The work in the area of imaging systems will initially focus on the imaging of biological structures at the cellular level. The electron microscope facility described below is the laboratory where the majority of this work is conducted. Professor Alan C. Nelson, a biophysicist who holds a joint

appointment in the Department of Nuclear Engineering, has assumed primary responsibility for this effort. He is assisted by a faculty steering committee with membership from the Schools of Science, Engineering, and Humanities and Social Science.

Work in the physiology of the cardiovascular and respiratory systems is led by Professor Richard Cohen, who holds a joint appointment in the Department of Physics. This work utilizes sophisticated methods of biomedical signal analysis to detect potential cardiovascular pathophysiologies, and determine, in a quantitative manner, the nature of the interaction between the cardiovascular system and the respiratory system. This work involves faculty, staff, and students in the Harvard-MIT Division of Health Sciences and Technology.

The Cryobiology Laboratory headed by Professor Ernest G. Cravalho, who holds a joint appointment in the Department of Mechanical Engineering, is engaged in researching the applications of low temperatures to biological systems. The major effort of this laboratory is devoted to the response of mammalian embryos to low temperatures. This research involves faculty and students in the Departments of Mechanical Engineering and Nuclear Engineering.

The work in the Division of Biophysics and Biomedical Engineering is housed on the third floor of Building E25. This floor also houses the computer facility of the College and two animal physiology laboratories used to conduct this and related research.

The Laboratory of Microscopy began operation as part of the biomedical research facility of the College during the past year. It is well equipped for light and electron microscopy, and offers state-of-the-art technology for specialized applications. Professor Nelson was appointed director of the Laboratory, and David Cummings, a senior electron microscopist from the University of California, was subsequently hired as research specialist for the Laboratory. A faculty steering committee with membership drawn from the Departments of Physics and Biology and the School of Engineering aids in formulating the budget and establishing policy and long-range planning for the Laboratory. New technologies in microscopy and their applications are being developed. During the past year, collaborative research has been initiated between the Laboratory and physicians at Harvard-affiliated hospitals and other university teaching hospitals in this vicinity. In addition, the Laboratory facilitates a research effort in a wide range of departments at MIT. Two recent developments should be noted: an environmental chamber is being developed to permit scanning electron microscopy of living tissue, and a mechanical cold-tip microprobe has been designed to facilitate microscopic sorting. Major emphasis has been placed on new technologies in computer-aided image analysis and automation, and this effort is likely to generate multiple software developments.

Professor Langer's research involves the development of new methods for delivering and removing drugs, and new approaches for drug development. Current areas of investigation include the following:

Drug delivery systems. A particular focus has been to develop polymeric systems for the long-term delivery (greater than one month) of large molecular weight drugs such as insulin, interferon, enzymes, and antigens. Studies which have been conducted have examined release kinetics, polymer microstructure, mathematical models, *in vivo* effectiveness, and approaches for achieving constant-rate delivery systems. A recent finding was the development of polymeric systems with release rates that could be externally modulated by magnetic fields.

Development of immobilized enzyme filters to remove potentially toxic chemicals from the bloodstream. One important example under study concerns the possibility of using immobilized heparinase to eliminate heparin. This approach could greatly enhance the safety of surgical procedures using extracorporeal medical machines (e.g., pump-oxygenator, renal dialyzer) by permitting heparinization of the machines without heparinization of the blood as it enters the patient. Microbial heparinase has been produced, purified, and covalently attached to blood-compatible materials. A blood filter containing heparinase has been developed and used to degrade over 99 percent of clinically used amounts of heparin in minutes, in both human blood *in vitro* and canine blood *in vivo*.

Isolation from cartilage of a substance that inhibits the growth of new blood vessels toward solid tumors. Approaches have been developed for partially purifying a substance which inhibits the growth of new blood vessels to solid tumors. This inhibitor has been infused into rats and rabbits, and has caused a more than 40-fold reduction in tumor growth.

Division of Human Biology and Experimental Medicine

This Division comprehends the research activities of Professors London, Monty Krieger, Robert Rosenberg, and Dr. Daniel H. Levin.

The goal of Professor Krieger's research continues to be understanding receptor-mediated endocytosis, a process by which animal cells internalize physiologically active macromolecules from extracellular fluid. Molecules as diverse as peptide hormones and transport proteins such as low density lipoprotein (LDL), the major cholesterol transport protein in humans, have been shown to be internalized by receptor-mediated endocytic pathways.

During the past year, activity has focused on four areas. First, Dr. Alan Leichtner, visiting scientist from Children's Hospital and Harvard Medical School, has developed procedures to modify LDL so that it is internalized by cells via the lysosomal enzyme receptor pathway. Using this modified LDL, selection for new mutants in receptor-mediated endocytosis will soon begin. Second, conditions are being developed for growing animal cells to permit detailed biochemical and genetic analysis of iron metabolism. Third, Christiane Nivet, a visiting scientist from the Pasteur Institute, has begun to explore the mechanism of complementation by co-cultivation expressed by LDL receptor-defective mutant CHO cells. Finally, plans are being made to extend our analysis of receptor-mediated endocytosis to the mechanism of virus internalization during infection, and to use the techniques of molecular genetics to isolate genes responsible for receptor-mediated endocytosis.

Professor Rosenberg's work has been directed toward elucidating the biochemical as well as physiological function of heparin and heparin-like molecules. In particular, he has studied the roles of these mucopolysaccharides in the thrombotic and atherosclerotic process. First, he has delineated a hexasaccharide sequence on the anticoagulantly active heparin molecule, which is responsible for the activation of antithrombin towards thrombin and factor IXa. This domain is distinct from the tetrasaccharide sequence which has previously been shown to represent the binding site for the protease inhibitor and to activate antithrombin towards factors Xa and XIa. Second, heparin-like molecules from the endothelium have been isolated, demonstrating that this material possesses anticoagulant activity and is capable of catalyzing the interaction of antithrombin with the various proteases of the coagulation cascade. Third, it has been demonstrated that heparin species which exhibit no anticoagulant activity possess the ability to inhibit smooth muscle cell proliferation initiated by platelet-derived growth factor under *in vivo* and *in vitro* conditions. It also has been shown that endothelial cells in culture are able to produce heparin-like substances with the above biological activity. Furthermore, a lysosomal enzyme has been isolated which is instrumental in releasing these molecules from the cellular elements. Since smooth muscle cell proliferation represents an early event in the development of the atherosclerotic lesion, heparin-like molecules may play a critical physiologic role in the suppression of the atherosclerotic process.

Professor London, Dr. Levin, and their associates are engaged in studies on the regulation of protein synthesis at the level of translation. Their studies are concerned with the role of phosphorylation in the regulation of the mechanism of initiation in eukaryotic cells. These mechanisms involve the heme-regulated protein kinase and the double-stranded RNA-regulated protein kinase, both of which phosphorylate eIF-2, the initiation factor involved in the first steps of protein synthesis. In addition, Dr. Jane-Jane Chen is studying the mechanism of differentiation involved in the conversion of fibroblasts to adipocytes, and the role of heme and phosphorylation in this process of differentiation. Dr. Ray Petryshyn is studying the role of phosphatases in the regulation of initiating protein synthesis. Drs. Dorothy Tuan and William Solomon are studying the genetic regulation of globin synthesis in thalassemia and related human hematologic disorders. Dr. Robert Matts is engaged in the study of a recently described initiation factor which plays a crucial role in the regulation of initiating protein synthesis. Dr. H.Y. Tan has been successful in preparing homogeneously pure heme-regulated eIF-2α kinase, an important step in the further study of the structure and function of this enzyme.

Division of Neurosciences

Neurobiology. A search committee chaired by Professors Ann Graybiel and Richard J. Wurtman has been engaged in the search and recruitment of faculty members in the area of molecular and cellular biology of the nervous system. This intensive effort is bearing fruit, and new appointments should be made during the coming academic year.

Communication Sciences. Through a private donation, an Eaton-Peabody professorship has been established, providing a continuing faculty position for someone associated with the Eaton-Peabody Laboratory of Auditory Physiology. The first holder of this chair will have a primary appointment in the Whitaker College with a secondary appointment in the Department of Psychology.

A formal propsal is being prepared for a new graduate teaching program in communication sciences. This program is being formulated by a group led by Dr. N.Y.S. Kiang, including Professors Kenneth N. Stevens, Louis D. Braida, and William T. Peake from the Department of Electrical Engineering and Computer Science. This group represents three major research units in the Research Laboratory of Electronics concerned with speech communication, auditory psychophysics, and auditory physiology. As presently conceived, the plan is to create a five-year graduate program leading to a doctorate in the communication sciences. The intent is to train students for research careers in communication, with a predominant emphasis on speech and hearing. How such a program would draw on the resources of Harvard (in addition to MIT) is one of the issues being discussed currently. Preliminary discussions with some of the key chairmen and deans at Harvard Medical School have received warm receptions, and these talks will continue. The identification of junior faculty now at MIT and Harvard Medical School who may play roles in this teaching program is currently under review.

Division of Health Policy and Management

This past year has witnessed significant activity in the development of the planned Ph.D Program in Health Policy and Management, funded by a generous grant of the Kaiser Family Foundation. The program executive committee, under the chairmanship of Professor Roberts of the Sloan School of Management, has initiated three searches for junior faculty in the areas of biostatistics and epidemiology, analysis of health technology, and organization and management of health care delivery. Each search has been undertaken in collaboration with one or more MIT departments with which joint appointments are anticipated. In addition, a search is under way for filling the position of program manager and director of the proposed Laboratory for Health Care Studies, an integral part of the new Ph.D program.

Two series of seed-research grants have been awarded to MIT faculty as a result of Institute-wide competitions, using funds from the Kaiser grant. These awards, totaling 11 in the two series, have extensively broadened the base of MIT faculty research in the areas of health policy and management, including faculty from biology and electrical engineering, in addition to the earlier base in economics, management, and political science. Initial progress reports on several of these projects have been made to the new monthly research seminar, initiated this past year under the chairmanship of Professor Sapolsky of the Department of Political Science.

The formal proposal for the new Ph.D program has now been approved by the Committee on New and Experimental Programs of the MIT Committee on Graduate School Policy. Submission to the faculty as a whole is expected early in the fall semester, with hoped-for admission of the first group of Ph.D candidates in September 1983.

During the past year, a major effort was devoted to working with architects, engineers, and craftsmen who were involved in the completion of the new building, E25. Construction details included not only the appointments for the various offices and laboratories, but also installation of a new computer facility and a new electron microscope facility. The new computer facility, housed on the third floor of E25, consists of a Digital Equipment Corporation VAX 11/780 main frame computer, complete with peripheral hardware for printed output. No graphics capability has been installed yet. Since the system is dedicated to the health sciences, technology, and management, the installed operating system includes software for word processing, biostatistics, signal analysis, and DNA sequencing. At the present time, 17 terminals are installed in Building E25 and provide ready computer access for faculty, staff, and students. The system is also being made available to users outside the College on a fee-for-service basis.

IRVING M. LONDON

Independent Activities Period

Volunteers from throughout the Institute organized a record-breaking 629 activities for the 1982 Independent Activities Period (IAP), January 4-27. This, the 12th IAP, also saw an increase in faculty participation in *Guide* activities, with 25 percent of the MIT faculty listed in the *IAP Final Guide*. This faculty participation rate -- a three percent increase over the previous year's -- reversed a nine-year downward trend, and equaled the 1977 rate.

In April 1981, the IAP Policy Committee issued a four-year report to the faculty in which it expressed concern that the number of faculty participating in *Guide* activities had gradually slipped from about one-third of the faculty in 1974 to slightly more than one-fifth in 1981. The IAP Policy Committee is encouraged by the growth in this year's participation rate to one-fourth. Apparently, the report and the discussions it engendered have increased awareness that, over time, IAP has become for faculty primarily a time to catch up on ongoing commitments. One of the original purposes of IAP -- providing opportunities for experimentation in teaching and learning and for informal interactions between students and faculty -- needs to be reemphasized.

Most of the credit for the revitalization of departmental IAP programs belongs to the IAP coordinators. This year the number of activities offered by the academic departments rose from 209 to 236, while the offerings from centers and laboratories increased from 165 to 205.

In addition, there were 188 independent offerings, 30 more than in the previous year. This increase may have been due to additional efforts by the IAP staff and the IAP Policy and Administrative committees to encourage more students to lead activities. Interviews with students, which were conducted as part of the IAP Policy Committee's four-year evaluation, had revealed that a suprising number were unaware that they can organize activities and receive funding to support them. To increase student leadership of *Guide* activities, a mailing was sent to leaders of student activities, and two "IAP Days" were held in Lobby 10, with members of the IAP Policy and Administrative committees on hand to talk to passersby. Maryglenn Vincens, staff writer/editor, had simple directions for organizing activities printed on bright yellow bookmarks which were distributed to freshmen during R/O week, in the main lobbies, and by coordinators in the departments.

Even with the large increase in the total number of activities, most leaders continued to be satisfied with participation in their particular activities. Of the 405 activity leaders completing the annual activity leader's questionnaire, 72 percent said participation equalled or surpassed their expectations, and an impressive 90 percent said their activities were worth the effort involved in organizing them.

As always, there were so many exciting offerings that it is impossible to cite even a few. Activity topics continued to range from the latest crazes (Rubik's Cube) to serious academic subjects (Computer-Aided Analysis of Geotechnical Engineering Problems).

Usually it is snow and cold which interrupt IAP activities, but this year a major earthquake in New Brunswick, Canada on January 9 was the natural event "felt" by IAP '82 participants. Five days after the earthquake, an historical presentation on "The Boston Earthquake of 1755" by Professor Keiiti Aki became a live event as the audience itself experienced a substantial aftershock of the recent earthquake. No one said anything -- apparently, even while listening to an account of an earthquake 200 years ago, no one connected the vibrations with an earthquake until Professor M. Nafi Toksoz, director of MIT's George R. Wallace Geophysical Observatory (who was in the audience), received a message reporting the aftershock. When the lecture was over, he announced that there had been an aftershock, and members of the audience were then able to see readouts on the tremors they had just experienced, but not recognized.

Because the New Brunswick earthquake occurred during the first week of IAP, Professor Toksoz was able to spend many hours monitoring and analyzing data on the largest earthquake in the New England-Eastern Canada area since 1925. A team of three graduate students and one undergraduate was also able to travel to New Brunswick to look for field evidence of the quake, and to evaluate the level of the damage.

This year, in addition to group activities, the IAP Policy Committee tried to encourage the "independent" part of IAP by asking coordinators to list books that students might read on their own. Members of the IAP Policy Committee also offered their own reading lists.

The 1981-82 IAP Policy Committee included Professors Daniel S. Kemp (chairperson), Edward B. Allen, Catherine V. Chvany, Charles L. Cooney; Ms. Mary Z. Enterline (staff); Professors Shaoul Ezekiel, Christos Georgakis, and Kenneth Hale; Dr. Merton J. Kahne; Professors Henry W. Kendall, and Harvey F. Lodish; Dr. Louis Menand III; Professors Edward W. Merrill, David Michael, Charles F. Sabel, and David Gordon Wilson.

The IAP Administrative Committee is made up of staff and student volunteers from various departments and administrative groups. This year's Administrative Committee was composed of Margaret S. Richardson (chairperson); Elizabeth C. Bradley; Ms. Enterline; Kristin Foss, Class of 1983; Edward J. Gaudiano; Patricia Joffee; Trond H. Kaalstad; Dr. Menand; Angela M. Price; Lawrence W. Ryan, Jr.; Michael E. Schlein, Class of 1983; Clifford A. Truesdell; and Ms. Vincens.

Dr. Menand, special assistant to the Provost, continued to chair the IAP Planning Committee which is composed of departmental coordinators. Operation of IAP is supervised by Ms. Enterline, manager of IAP and the Wellesley Exchange. Ms. Vincens, staff writer/editor, is responsible for IAP publications. The office was held together and made to work by Ms. Price, senior office assistant, who left in March. George R. Kendall succeeded her in April.

MARY Z. ENTERLINE

Information Processing Services

During the past year we began preliminary plans to move the computer facility from our Building 39 location, to make room for the new Very Large Scale Integrated Circuit (VLSI) facility. Although a number of alternative sites were available, the final selection for housing hardware operations and systems programming was Building W91. This building currently houses a supersonic wind tunnel and requires extensive renovations in order to meet the needs of a computer installation. Completion of the work is scheduled for late winter 1983 and we expect to move in during March or April of 1983.

Office facilities for user services, consulting, and user accounting are currently planned for Building 11, which is conveniently located off the main corridors of the Institute, offering an ideal location for students, faculty, and staff to use the computing resources.

The following summarizes highlights of activities in Information Processing Services (IPS) during fiscal year 1982.

Academic and Research Computing

Non-credit courses open to the entire MIT community continue to be extremely popular. In addition to the highly technical offerings which we have concentrated on in the past, we are now offering an introductory course primarily to Institute support staff who are experiencing greater exposure to computers and data processing. This new course is repeatedly oversubscribed, requiring more than one section.

Along these same lines, a special, informal course in computers and information systems was given this past fall through the Dean of Engineering's Office to the administrative officers of departments in the School of Engineering. This course ran for 16 weeks and included a text geared to the introduction of business data processing. The course now will be offered through the Personnel Department's career development program on a regualr basis.

Our statistical and numerical technical support area, enhanced during 1981 through the formation of an interdisciplinary user forum, continues to meet with great success within our

user community. The continuation of this informal group has made us more closely aware of the needs and problems of our users, and has enabled us to be more active than reactive in fixing bugs and selecting the most appropriate software and sub-systems.

With our technical and administrative help, the Sloan School of Management successfully installed a Prime 850 computer system to replace the Prime 400, which could no longer support the demands for computing within the east campus community. Our operational and technical support team assisted in the installation of the hardware and transfer of all users and their files to the new equipment. Arrangements were then made through this office to sell the replaced equipment to Bates College in Lewiston, ME.

Computer Operations

Although no major changes were made in our mainframe computers (the IBM 370/168 and the Honeywell Level 68 Multics), we did make two major improvements in the user output area.

First, we installed a XEROX 9700 laser printer, replacing the XEROX 1200. Our printed output on the 9700 now averages 1,200,000 pages per month. This new printer prints on both sides of the paper, in landscape or portrait mode, and offers proportional spacing for left and right-hand margins as well as a variety of type fonts and graphics.

Although we installed our Nicollett-Zeta plotter in 1981, it was not until this year that we were able to fully support the device. During 1982, we installed the plotter on-line to the 370/168 and the necessary telecommunications connections to Multics for faster turnaround.

Systems Programming

"Full screen" capabilities were provided to on-line users of our 370/168 through the installation of an IBM Series 1 computer and the emulation software developed at Yale University. This new installation allows users with standard ASCII terminals to use the hardware and software capabilities available on the 370/168, formerly usable only by those with expensive terminals.

This capability on the Series 1, combined with the editing and formatting software designed for use on the IBM laser Printer Model 6670, has now allowed full text processing capabilities to the entire IBM-user community. The 6670 software was modified to use the new Xerox 9700, and we were able to release the Model 6670 Printer during the year at a significant cost savings. Few if any problems have been experienced in the use of the 9700.

Efforts in developing our Multics relational data management software, RDMS III, proved to be sufficient to the extent that the School of Engineering has adopted this system as the basic information system for all departments in the School. A task force comprised of Professors Fernando Corbato, Joel Moses, Frederick Hennie, and Mr. Weston Burner reviewed the requirements of the School and all possible alternative subsystems, both relational and hierarchical. RDMS III appeared to be the best choice for the School from both a financial and technical capability basis.

In conjunction with EDUCOM, the Inter-university Communications Council, IPS has begun the development of Mailnet. Mailnet is an inter-university communications system to be operated on an international level, providing a common telecommunications link among the local electronic mail systems of 16 pilot installations. Using the Multics System as a hub, electronic mail will be automatically picked up and delivered to particpating schools. The project is jointly sponsored by the Carnegie Foundation and the pilot colleges and universities.

Administrative Data Processing

July 1981 marked the beginning of Administrative Information Systems (AIS), the successor to Administrative Computing Services (ACS) and Business Systems Development (BSD). The resulting organization closely parallels the recommendation of the 1980 EDUCOM Consulting Group.

One of our foremost accomplishments this year was the turning over of the Admissions, Alumni/Gifts, and hourly and weekly payrolls to production usage. Several years of hard work in building an applications environment for developing on-line interactive ADABAS systems began to pay off. We were further encouraged when we were able to produce in a matter of months two ADABAS-based systems, one for the task-oriented budgeting process and one for travel.

The Administrative Information Systems Steering Committee has strongly supported our effort this past year. They authorized the expenditure of funds to upgrade our IBM 4331 and IBM 4341-L1 to an IBM 4341-L1 and IBM 4341-M2 respectively. This allowed us to alleviate serious response-time problems being experienced by clients of our new systems. In addition, they authorized the expenditure of funds for several new staff members in critical application areas and in database administration.

To assure that we are better prepared to deal with hardware capacity and performance problems such as those noted above, we began a hardware planning effort. Such an effort has a sizable start-up time, and we feel that it will take most of fiscal year 1983 to see some solid results.

While we were enjoying our successes, we met our next challenge head-on. Although our new systems are being used in production, we have not created a necessary and sufficent production environment. Since clients themselves are controlling some of their own production, we need to provide more training and end-user documentation, develop new scheduling mechanisms, and be on call to troubleshoot production problems. As clients enhance their own systems through the use of end-user software, we need to provide standards and guidelines. We have begun to address these issues with the establishment of a documentation group and the periodic availability of in-house courses.

Although we are excited about our new on-line systems, our old workhorse, the IBM 370/148 continues to serve well. During the daytime shift the machine is usually backlogged, and interactive response is frequently below acceptable levels. Even though we are beginning to move work off the IBM 370/148, usage of the student system and the financial systems has been expanding rapidly.

General

IPS currently operates with approximately 170 equivalent full-time employees, with a total headcount of 173.

Once again, turnover within the staff has posed a serious problem for us, as the demand for computing and data processing personnel within the Boston area remains high. Our turnover rate was 17 percent, down a bit from 1981. However, it did affect our distribution of minority and female employees, causing us to fall short of our 1982 planned goals. Statistics are as follows:

	1982 Actual	1982 Goal
Number of Employees	173	176
Number of Women	61	68
Percentage of Women	35%	39%
Number of Minorities	15	24
Percentage of Minorities	9%	14%

WESTON J. BURNER
JOSEPH R. STEINBERG
JEAN C. BONNEY

Joint Program in Oceanography and Oceanographic Engineering

The past year has seen some major changes in the Joint Program in Oceanography and Oceanographic Engineering between the Woods Hole Oceanographic Institution (WHOI) and MIT. In an effort to implement the recommendations of the Hollister/Wadleigh Report which reviewed the Joint Program, major steps have been made to a) improve the visibility of the Program at MIT, b) centralize communications with WHOI, and c) return the decision-making processes to the level of the individual disciplines as much as possible.

The above steps have been implemented by the following changes. First, an Office of the Director at MIT has been set up. This office reports through Associate Provost Frank Perkins to the Provost at MIT, and complements the Dean's Office at WHOI. Professor John G. Sclater was appointed director in September 1981. The MIT administrator of the Program is Mary Athanis. The office is located in Room 26-167.

Second, a Faculty Advisory Committee on Oceanography at MIT has been set up. This committee complements the Educational Council at WHOI and advises the Director's and Provost's offices at MIT with regard to oceanographic matters. It consists of at least one faculty member from each of the individual disciplines covered in the program (biological oceanography, chemical oceanography, marine geology and geophysics, oceanographic engineering, and physical oceanography), and a representative of the department administrators at MIT (currently from the Department of Earth and Planetary Sciences). Associate Provost Perkins, the dean and associate dean at WHOI, and the director and administrator of the Joint Program at MIT are ex-officio members. The committee meets once per term and is chaired by the MIT director. The committee provides MIT with a central group where Institute-wide decisions regarding the Joint Program can be discussed.

Third, a new committee structure for the Joint Program has been established. Overall policy, financial support, quality control, and final admission of students are controlled by a program-wide Joint Program Committee, which is cochaired by the WHOI dean and the MIT director. The committee itself is made up of the chairmen of the five disciplinary committees, the dean, associate dean, and education coordinator at WHOI, and the director and administrator at MIT.

The actual handling of the students, student advising, curricula, exams, and student admissions are the responsibility of five disciplinary committees representing the five disciplines in the Program. The members of these committees are chosen by the respective department chairmen at MIT and WHOI in consultation with the WHOI dean and the MIT director. In addition, the associate dean at WHOI and the administrator at MIT attend all meetings of these five committees.

Currently, about 40 faculty at MIT from nine departments (Biology, Earth and Planetary Sciences, Meteorology and Physical Oceanography, Chemical Engineering, Civil Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Ocean Engineering) are involved in the Program. There are 98 students currently registered in the Program, about half of whom reside at MIT during term time. The number of students per discipline is almost equal, with biological oceanography, physical oceanography, and oceanographic engineering having 22 students each, marine geology and geophysics having 17, and chemical oceanography having 15.

The major concerns of the program are a) improving communication with WHOI, b) establishing a more uniform decision-making process across the five disciplines, and c) trying to improve the funding basis of the program at MIT. Concerning communication, a project to provide a microwave link between the two campuses is being implemented. In addition, a fund-raising plan for the Program is currently under consideration.

JOHN G. SCLATER

Libraries

A principal measure of the success of a large academic research library is the degree to which the informational needs of its users are being addressed and satisfied. Quantitative indicators of effectiveness directly related to user satisfaction are difficult to find, although such factors as circulation, reference inquiries, literature searches, and the like do provide some overall view of the level of activity. An important indicator of a successful research library may, however, be the absence of "noise" in the system. Noise consists of a whole series of problems including missing material, slow response to requests, or the breakdown of part of the operation. A review of the MIT Libraries' activities for the academic year ending June 30, 1982, revealed a relatively "quiet" year insofar as service to the user community is concerned. The successful completion of another year of providing for the informational needs of the MIT community is due in large part to the dedicated and conscientious efforts of the more than 200 members of the regular staff, as well as the many student assistants, all of whose efforts contributed to the progress of the Libraries.

Invisible to the user community, however, are the numerous and complicated intellectual and physical activities that take place "behind the scenes" but without which there could be no library system. The seemingly simple process of adding a new monograph to the collections, for example, involves efforts in a wide range of skills and expertise including collection development, acquisitions, cataloguing, and processing. In each of these areas are philosophical and procedural foundations built up carefully over a period of years and constantly reviewed, evaluated, and changed to reflect the dynamic needs of the Libraries' users within the context of the changing technology and evolving library systems. In order to support the many and varied activities of the MIT Libraries, there is an ongoing requirement for planning and evaluation, for sensitivity to changes in research and educational programs, for adaptation of new national standards and systems, and for imaginative and innovative solutions to new problems. As the summary of major activities for the past year will indicate, 1981-82 was a most significant year for the MIT Libraries in terms of adaptation and change.

A number of major efforts initiated in earlier years concluded during the past year while others continued at various levels of activity. Highly significant was completion of the installation of the 3M book security system in the Barker, Dewey, Humanities, Rotch, and Science libraries and in the Student Center Library. While it is still too early to provide detailed data on the impact of this system on reducing the loss rate of library materials, there are indications of positive effects. In addition, the response of patrons has been overwhelmingly supportive.

In the realm of internal planning and organization, the Library Council, consisting of the senior administration and department heads, began work on the establishment of goals and objectives statements for every element of the library system, and initiated a series of periodic all-day "retreats." One of these meetings concentrated on a review of planning activities and resulted in the development of a document on the planning process.

One of the most significant developments in the history of the MIT Libraries took place during the past year: the decision by the Institute administration to support the development and installation of an automated circulation system as the first step toward automated bibliographic control. With funds provided through the Sustaining Fellows Program, the Libraries will, probably by the end of calendar 1983, install a turnkey circulation system in all component libraries. The expectation is that, given the necessary fiscal resources, this will be followed by development of an on-line catalogue covering acquisitions from 1964 to date. Concurrent with developing specifications for the circulation system is the planning for retrospective conversion of bibliographic records not presently in machine-readable form. Serious consideration is being given in this regard to the use of the REMARC database marketed by Carrollton Press. As the MIT Libraries look ahead to the exciting prospect of an on-line bibliographic system, it is gratifying to realize that the national context in which this will take place has markedly improved in character during the past year. The two most significant developments were the announcement by the Online Computer Library Center (OCLC) of a new policy providing for tape-loading of bibliographic records, and the formal

establishment of an OCLC Advisory Group on Research Libraries. The first change will provide for a means of linking the OCLC and the Research Libraries Group (RLG) databases, with a resultant improvement in bibliographic access and interlibrary loan capability. The establishment of a formal advisory body in OCLC for research libraries ensures that this group of approximately 75 libraries will have direct input to planning, policy development, and operations at OCLC.

Planning continued during the past year for occupancy of the former Nabisco Building (N57), as the permanent locus for the Resource Sharing Center (RSC). The prospect of relocating the collections housed in Buildings N51 and N52 by the end of calendar 1982 is viewed with great anticipation and relief, because the space now available for storage of less-used material is fully assigned. In order to provide more effective access to material stored in the RSC, as well as to improve the delivery of library materials throughout the system, the Libraries will acquire a delivery van during the coming academic year. Other space changes that are either imminent or under way are the renovation of the reserve book area in the Barker Library to provide additional staff offices and the installation of much-needed stacks in the former seminar room of the Music Library. A unit was added to the library system during the year when the Schering-Plough Library was opened in March in the new Health Sciences/Health Services complex. This facility will serve as a reading room primarily for the health-related activities located in the new buildings, and for the Medical Department. The rare book collections, housed until June 1982 in the Boston Public Library, were transferred to the special collections area in Hayden Library. Finally, on the negative side, no substantive progress was made with regard to providing additional space for the Rotch Library of Architecture and Planning, but the prospect for a solution was considerably enhanced by the attention being given to this issue by the new Dean of the School of Architecture and Planning.

Three sponspored research projects were completed during the year. The Boston Composers Project, supported by a grant from the National Endowment for the Humanities (NEH), ended with the completion of the manuscript of a directory of works by Boston-area composers, which will be published by the MIT Press. Another grant from NEH, in this case to the Institute Archives, was also completed with the organization, processing, and preservation of 20 collections with a total of 528 linear feet of material. The grant also resulted in the development of a processing manual and the publication of an article on the project in the *American Archivist*. The third was an NEH grant to the MIT Museum for an exhibit of eighteenth-century scientific instruments.

Near the end of the academic year, the MIT Libraries received notification of the award of two new grants. The first is a grant from the US Office of Education under Title II-C of the Higher Education Act for a series of activities connected with collections on technology and society. The grant will support retrospective conversion into machine-readable form of bibliographic records of books in the fields of computers and society, energy, applied genetics, the history of technology and applied science, and technology transfer. Funds will also be provided for the processing of manuscript collections related to these five areas, and for the preservation of manuscripts, monographs, and photographs. The second grant, from the Andrew W. Mellon Foundation, will support activities in the Institute Archives related to appraisal guidelines for scientific records. The grant will complement activities already under way in the Archives supported by funding from the National Science Foundation.

Two major research projects were initiated in the Aga Khan Documentation Center, both involving computer-based information retrieval. The first was the establishment of a projects directory which is designed to be an on-line inventory of current and recently completed building and restoration projects in Islamic countries. The second, a more extensive and complicated endeavor, involves the design and development of a visual documents database using the field of Islamic architecture as the test bed. The two major foci of the second project are the development and application of a thesaurus of Islamic architecture and experimentation with optical and video discs as storage media for the source images.

One very important aspect of library activity that is by and large invisible to those outside the organization, is the work of a number of standing and ad hoc committees. Many members of the staff are involved in one or more of these groups, which contribute measurably to both the ongoing operations of the system and to planning and development activities. While by no means a complete inventory of activities, the following list will provide some insight into the contribution that committees make to the successful operation of the MIT Libraries.

1) Circulation Committee -- major involvement with specifications for automated circulation system; revised *Circulation Manual*; worked on minimum billing charge; reserve procedures, and bookkeeping methods.

2) Collections Advisory Group -- worked on budget allocation procedures, developed guidelines for allocation of special monies for collection development, and involved in planning for October 1982, Regional Collection Management and Development Institute to be held at MIT.

3) Branch Librarians Group -- involved with circulation system, serials control, and technical services.

4) Divisional Librarians Group -- major concerns were on-line reference services, cataloguing issues, security, allocation of staff time, services to outside users, automated circulation, and Collection Analysis Project review.

5) Joint Committee on Technical Processing -- concerns included AACR2 (Anglo-American Cataloguing Rules 2) orientation and training, binding and preservation, acquisitions procedures, and pre-order searching.

6) Reference and Information Services Committee -- involved with staff education seminars, marketing of library services, levels of reference and information services, and international student orientation.

7) Staff Development Committee -- conducted needs assessment of staff, sponsored workshop on time management, and conducted session on meetings with accompanying film.

The work of these committees is indispensable to the successful operation of the MIT Libraries and is dependent upon the contributions made not only by those directly involved but also by the entire staff of the Libraries who keep the operations running smoothly during committee meetings and provide ideas to committee members.

Among the other significant developments and activities during the past year were the following:

1) The second extensive review of the Collection Analysis Project and its impact on the Libraries was conducted by a special study team.

2) Establishment of a binding and repair section in RSC, several in-house workshops on binding and repair, inauguration of brittle book projects, and institution of annual presentations in each unit of the library system on care and handling of library materials.

3) Participation in the F. W. Faxon LINX system as a test site; the system involves searching, claiming, ordering, and verification of serial titles, and electronic mail.

4) The removal and reduction of backlogs in the Catalogue Department, including elimination of the backlog in thesis cataloguing, filing, and subject authority work; the production of two issues of *Serials in the MIT Libraries* on or ahead of schedule; and reduction of the pre-cataloguing backlog by 20 percent.

5) Initiation of a course in research methods as part of the Undergraduate Seminar Program in fall 1981; this is the first for-credit course in library methods ever provided at MIT.

6) Publication of the first *Repository Guide* to holdings of the Institute Archives.

7) Thirty exhibits mounted by the MIT Museum and Historical Collections, including four in Compton Gallery, three in the Hart Nautical Galleries, ten in the Museum, five for other MIT departments, six in the Lobby 7 area, and two traveling exhibits.

8) The award of a Kurzweil reading machine to MIT by the Xerox Corporation; to be delivered in early fall 1982.

9) A successful book sale, conducted for the first time in the Hayden Gallery.

10) A successful set of Independent Activities Period programs including ones on music, painting, primary sources for research, thesis preparation, fantasy films, great books, the *Social Sciences Citation Index*, career planning, astrology, needlework, "How MIT Works," neighborhood documentation, and library skills for secretarial staff.

In the area of personnel, a most significant event was the selection of Sylvia A. McDowell, Librarian of the Student Center Library, as a recipient of a 1982 Boston YMCA Black Achievers Award. During the year, the Libraries were host to Karen Wittenborg, Curator of Social Sciences in the Stanford University Libraries, as a Council on Library Resources Academic Library Management Intern. Appointments to the librarian staff included Dorothy DeSimone, Assistant Science Librarian; Kristin Djorup, Assistant Dewey Librarian; Jeanne Duperreault, Reference Librarian in the Museum; Joan Haas, Archival/Manuscript Specialist; Nancy Kaufer, Records Management Officer; Kathleen Marquis, Reference Archivist; Naomi Preheim, Business Services Officer; Donna Webber, Assistant Archivist; and Lenis Williams, Documentation Projects Librarian in the Aga Khan Program. Kate Herzog, formerly Librarian of the Aeronautics and Astronautics Library, was appointed Associate Engineering Librarian. Two members of the staff, Aleksander Leyfell, Social Sciences Literature Specialist in the Dewey Library, and Patricia Sheehan, Systems Designer, retired. Suanne W. Muehlner, Assistant Director of Libraries for Public Services, resigned in August 1981, to become Director of the Colby College Library in Waterville, Maine and will be succeeded on July 1, 1982, by Shirley K. Baker, Special Projects/Access Librarian at Johns Hopkins University. A complete list of staff changes is available in the archival version of this report.

Among gifts made to the libraries during the past year were those provided by Frank P. Davidson for the establishment of a fund for a Mountain Environment Collection in the Dewey Library, and by the family and friends of the late Mack Morikawa who established an endowed fund in his memory for the purchase of materials in urban design in the Rotch Library; the papers of Georgio de Santillana given to the Archives by his family; and new collections of papers of Harold L. Hazen, Thomas F. Jones, Jr., Catherine Nelson Stratton, A. Gallatin Thomas, and David Oakes Woodbury. Additions to existing manuscript collections included those of William A. Baker, Harold E. Edgerton, Robley D. Evans, Arthur T. Ippen, Walter A. Rosenblith, Robert R. Shrock, Robert J. Van de Graaf, and Carroll L. Wilson. A complete list of donors appears in the archival version of this report.

Looking ahead to the next academic year, the Libraries will have a considerable number of new activities to address as well as continuing with many of the programs and projects outlined in this report. Three areas will occupy much attention. As a member of the Boston Library Consortium, the MIT Libraries will participate in a pilot demonstration project of an on-line union list of serials being developed in cooperation with the F. W. Faxon Company. A second effort will be furthering the utilization of on-line databases to support reference activity. Finally, the Libraries will be evaluating the amount and level of service provided to industrial users in the context of possible centralization of activities and/or establishment of a technical information service.

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. Entry-level courses require an adequate high school preparation, and the more advanced 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 seven-course program of study in the fields of Drafting Technology and Electronics Technology.

During 1981-82, LIS offered 31 evening courses in the fall term and 33 in the spring term. The fields of instruction included analog and digital electronics, including microprocessors through advanced applications; blueprint reading; technical illustration; mechanical , electrical, and architectural drafting; machine tools, including numerical control; quality assurance; metal joining; welding/fabricating; scientific glassblowing; effective speaking; printed circuit board design; and creative photography. New courses were introduced in computer programming, desktop computer applications, word processing, and building maintenance. In addition, refresher courses were offered in mathematics to support both the drafting and electronics curricula.

LIS continued to offer intensive one-week daytime courses in the microprocessors area for individuals working in industry. Two were at the introductory level, conducted in cooperation with the Boston section of the Instutute of Electrical and Electronics Engineers, and three at the advanced level, one of which was taught off campus at the Bell Telephone Laboratories in North Andover.

LIS admitted a total of 1,525 students to its courses in 1981-82, 1,458 to the evening classes and 67 to the intensive daytime courses. Of those who enrolled, 78 percent successfully completed the certificate requirements. Among those who completed courses were 62 MIT employees and three regular MIT students. Ten students earned the Special Certificate in Electronics Technology, and seven students earned the Special Certificate in Drafting Technology.

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 ninth 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 principal objective of the Mining and Minerals Resources Research Institute (MMRRI) of MIT is to encourage and support new initiatives in research and teaching across MIT's organization in areas related to mineral resources. Funds that have been available this year have been utilized for the support of research and graduate fellowships in a number of departments in accordance with this objective. In addition, the Bureau of Mines of the US Department of the Interior has provided financial support for specific research projects. It is to be noted that this year the Federal MMRRI Program was transferred by act of Congress from the Office of Surface Mining to the Bureau of Mines.

Four research projects that have received support from the Department of the Interior on the Mining and Mineral Resources Research Program have been continued, or have been completed this year. The study of probabilistic methods of mineral exploration was completed; Professors Daniele Veneziano and Rafael L. Bras of the Department of Civil Engineering are the principal investigators for this program. It was found that linear kriging with instrinsic random functions is by far the most accurate and robust procedure for estimating the size and value of an ore body from data of various sorts on the nature of the body. This procedure is superior to the methods that traditionally have been employed for that purpose. Research on the combined stability-deformation analysis for rock slopes in open pit and strip mines is to be completed during 1982 by Professors Herbert H. Einstein and Gregory B. Baecher of the Department of Civil Engineering. The research includes a case study of a major instability under the ground in a copper porphyry mine in the American Southwest. A study titled "The Competitive Position of the United States Copper

Industry: 1980-2000," by Professor Joel P. Clark of the Department of Materials Science and Engineering, is being completed this year as well. In the program of study of the flow of gases and solids and heat transfer characteristics of a fast fluidized bed, the reactor (8 in. diameter by 30 ft. high) was completed and placed in operation this year. The work is directed by Professor John F. Elliott of the Department of Materials Science and Engineering.

Funds from the MMRRI program were used for the support of eight graduate students working in new areas of research in minerals-related activities. These students are in the Departments of Civil Engineering, Mechanical Engineering, Materials Science and Engineering, and Earth and Planetary Sciences.

Limited funds also have been used to purchase capital equipment for programs in mineral engineering, rock mechanics, and underground excavation and mining systems. The purchases covered equipment that was urgently needed by a project or was to be used in starting up new research activities.

The 22nd US Symposium on Rock Mechanics was held at MIT during the summer of 1981, and Professor Einstein of the Department of Civil Engineering was its chairman. The Symposium received financial support from several organizations, including MMRRI.

Professor Terry Ring's program of Mineral Engineering in the Department of Materials Science and Engineering continued to receive major financial support from MMRRI funds.

Professor Elliott, director of the MMRRI, was named by the American Iron and Steel Institute as its Distinguished Professor. An unrestricted award of $75,000 to Professor Elliott accompanies this recognition.

JOHN F. ELLIOTT

Northeast Radio Observatory Corporation
Haystack Observatory

The Northeast Radio Observatory Corporation (NEROC) is a consortium of 12 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, MA, 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 operating at 18-, 13-, 6-, 3.8-, 3-, 2-, 1.35-, and 0.7-cm wavelength. 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.

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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 Stony Brook, University of Massachusetts, University of New Hampshire, and Yale University.

In the past year, the telescope was used by approximately 70 investigators from over 20 different institutions, and 50 articles were published in scientific journals based upon this work. Approximately 12 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. In particular, a low-noise (T_{sys}~100K) maser amplifier receiver on loan from the National Radio Astronomy Observatory (NRAO) was used to detect Isocyanic acid, HNCO, in the $2_{02} \rightarrow 1_{01}$ transition toward Sgr B2 at a frequency of 43.96 GHz. This marks the highest frequency at which successful observations have been conducted using the Haystack antenna. This receiver also was used to detect the HCS^+ radical in the dark cloud TMC1 and to study the ground state v=0 J=1 0 transition of SiO in regions of young star formation. The dense cores of dark clouds, possibly the sites of future star formation, and the galactic center region were studied using the inversion transitions of the NH_3 molecule. These transitions, which are closely spaced in frequency, require widely differing conditions for excitation, allowing molecular cloud parameters such as temperature and density, as well as dynamical information, to be obtained. The NH_3 emission also has been used to study the centers of high-velocity outflow in regions of low-mass star formation, in an attempt to define the focusing mechanism for the observed bipolar nature of the outflow. Other programs have included studies of the properties of interstellar masers at 43 GHz (SiO) and 22 GHz (H_2O).

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; the records made, using identical, special VLBI recording systems for 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. Haystack is a member of a VLBI network of seven observatories, which make astronomical VLBI observations every two months, and has developed a new recorder and processor (MK III) which yields a five-fold improvement in sensitivity over older ones. The network uses the Mark III VLBI system and the Mark III processor at Haystack for high sensitivity measurements, thereby extending fundamental research to fainter and more distant objects.

The high angular resolution afforded by VLBI allows the study of the motion in the central regions of many radio sources. The apparent internal motions are often faster than light or "superluminal," and may indicate that plasma is being ejected from a central core with speeds approaching that of light. Further studies of the "superluminal" phenomenon in radio jets, which was first discovered in the quasar 3C279 from VLBI observations between Haystack and the 64-meter telescope at Goldstone, CA, promise to reveal the true nature of the energy sources at the center of radio galaxies. VLBI studies using MK III show that most normal galaxies, including our own, have intensely bright radio emission at their centers. Recent improvements in the MK III VLBI processor at Haystack have included the efficient processing of pulsar and spectral line data. Phase reference VLBI techniques, in which a nearby calibration source is used as a reference, have further improved the sensitivity of VLBI. This technique has been used to great advantage in the study of the gravitational images of the quasar 0957+56. It has also been used to make maps of the pair of quasars 1038+528 A and B at several wavelengths. If motion occurs in 1038+528 A or B it should be possible to verify that the motion takes place in the jet extending from the core, while the core itself remains stationary.

With support from NASA, VLBI is being used to make precise geodetic measurements between Haystack, the 40-meter telescope at Owens Valley Radio Observatory, CA, the 26-meter telescope of the Harvard College Radio Observatory in Fort Davis, TX, the 100-meter telescope of the Max Planck Institute in Bonn, Germany, and the 20- 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, and they are expected to establish a precise drift rate between the North American and European plates in a few years. This network of fixed VLBI observatories is now being augmented by the addition of transportable stations. These new VLBI sites, which are to be located in California, will enable a detailed study of crustal motions in that state in the hope that an understanding of the motions will aid in the forecasting of earthquakes.

The 60-foot diameter Westford antenna, located one mile south of the 120-foot telescope, was operated as a dedicated VLBI station for the National Geodetic Survey (NGS). The POLARIS (Polar Analysis by Interferometric Surveying) Project measures changes in the absolute rotation rate of the earth

by measuring UT1, and the changing point of intersection of the earth's axis and the crust, or polar motion. Along with a station at Ft. Davis, these parameters are measured on a weekly basis to an r.m.s. accuracy of about 0.3 msec in UT1 and 15cm in the X-component of polar motion. The addition of a third site at Richmond, FL, (now under construction) will permit measurement of the Y-component of polar motion, as well. The Westford antenna, equipped with standard NASA receivers at 2.2 and 8.4 GHz, also participates regularly in the NASA Crustal Dynamics Project observations of continental and intercontinental baselines. 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 maintained programs and activities described below in order to continue the expansion of educational resources available to minority students and increase the number of minority students who graduate successfully. During the 1981-82 academic year, Clarence G. Williams completed his second year as acting director of OME. He also retained his position as Special Assistant to the President. Pearline D. Miller served as assistant director.

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

Advisory Structure

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 of existing programs and have made several worthwhile suggestions concerning student perspectives on OME support programs.

Project Interphase

Structurally, this program has remained unchanged from 1979. There were 45 participants during 1981. Professor Alan Davison continued to supervise the academic content of the program. Mrs. Miller had responsibility for overall direction of the program. As in past years, students received intense academic preparation in chemistry, humanities, mathematics, and physics. Instruction in computer programming was also offered to selected students. 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 continued to live 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 was distributed by OME in early spring to seek students' impressions of the impact of Project Interphase 1981 on their MIT experiences to that point, to help the Office plan for Project Interphase 1982, 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 Brenda Kitchen and Damion Wicker. The tutors are graduate and upperclass students; their services are arranged by the student coordinators and program secretaries under the general supervision of Mrs. Miller. In 1981-82, the program provided more than 4,000 hours of tutoring in more than 60 subjects.

The tutorial program is in its 11th year and its continued use and importance are clearly recognized by the increase in the number of subjects tutored each year.

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

Strategies and Secrets for Academic Success (SSAS)

SSAS is a two-part seminar series designed to promote academic achievement among undergraduate students. For the past two academic years, Gene A. Norman, Jr., student coordinator, implemented SSAS activities under the direction of Mrs. Miller.

During the fall, successful academic strategies were presented to the students. The spring sessions modified the academic topics discussed in the fall and applied them to the professional work experience.

The interaction between Institute faculty, administrators, role models from the private sector, and students provided a forum for dynamic discussions of time management, faculty-student interaction, professional development, and optimum use of Institute resources.

An additional session, co-sponsored with the Freshman Budddy System, examined the various Institute schools to assist students in understanding and choosing a department and/or possible career.

Freshman Watch

With the cooperation of faculty and staff who teach 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 advisor, and communication with each freshman advisor is maintained.

This program is probably the most important follow-up that this Office should pursue with the assistance of academic department faculties in the future. This same procedure may be helpful beyond the freshman year.

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. Seventeen students worked for 10 weeks at E.I. duPont de Nemours & Co., Goodyear Tire & Rubber Co., Hewlett Packard, IBM Corporation, and Eastman Kodak 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 well received by the students. The number of participants for 1982 is 18 students and five companies.

Activities

During the year, OME has sponsored a number of seminars and assisted students in planning various activities. These included: R/O Week activities in cooperation with the Black Student Union and the Mexican American Students Association with the objective of making the transition

into MIT as smooth as possible; 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.

Awards

OME selected Lisa Washington to receive the Monsanto Achievement Award as the third-year engineering student with the best academic record. The award consists of a plaque and a $500 award given by the Monsanto Company "to promote academic excellence among minority engineering students at MIT."

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 program. 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.

The past year has been a milestone year for the ORC. First, the Center has moved from its former location in Building 24 to a newly renovated building on the eastern end of the campus. The new building is called the Webster Building or "E40," and it contains a number of centers and laboratories in addition to the ORC. This new location will facilitate synergistic interaction between and among the various centers. Also this year ORC graduate students formed a student chapter of the Operations Research Society of America. This chapter promises to be one of the most active in the US, and will provide early professional communications between our students and others throughout the profession. Research activities at the Center this past year were impressive in their scope and depth, ranging from public sector applications, to analyses of manufacturing problems and theorectical advances in mathematical optimization theory. The following is a report on research at the Center and on other important topics of interest.

Public Sector Research

The ORC continues to be a national leader in applications of operations research techniques to problems of the public sector. During this past year research progress was made in such diverse areas as criminal justice, urban service systems, oil spills at sea, energy modeling, mental health case studies, methods for formally evaluating public programs, and traffic light synchronization.

A continuing strong component of ORC research has been the development and use of mathematical models for policy analysis in criminal justice. The research included new analyses of the ORC's decade-long monitoring of the homicide problem through the United States, which among other things has revealed suprisingly high probabilities that children born today in America's core cities and who live their entire lives in those cities will eventually die as homicide victims. The research also included new analytical techniques for performing deterrence-related research, in which one wants to obtain estimates of the net crime rate reduction due to interventions affecting the probability and/or extent of punishment. The ORC's criminal justice-related statistical research will continue for the next two years in the area of mathematical models applied to the present problem of overcrowded prison space throughout the US.

Substantial research continued in the area of urban service systems. Much of this work concerned determining the optimal location(s) of one or more facilities on a transportation network, in which the total operating system is stochastic in nature. Most previous and currently popular optimal location

models and algorithms are primarily deterministic and neglect temporal stochastic aspects of system operation. But in urban service systems such as urban emergency ambulance systems, the arrival time of a random service demand and the length of service requirement are both random quantities. These aspects of randomness can cause queueing to occur and can even lead to the loss of customers. Much of the work this year focused on locating a single facility housing a single mobile service unit on a transportation network, where the entire system operates as a so-called M/G/1 queue. Finite step procedures were developed for optimally locating this facility on a transportation network as a function of overall demand rate and other system parameters. In stark contrast to earlier deterministic location models, in which optimal locations are found almost always at transportation network nodes, this work has shown that quite often an optimal location occurs somewhere along a transportation link. Additional results in urban services research have occurred this year in the area of inhomogeneities in the travel medium; these can include barriers to travel (such as parks, cemeteries, or areas of a harborway) and high-speed travel links (such as interstate highways). For both barriers and for high-speed links, new results were obtained for optimally locating an arbitrary but finite number of facilities in the plane in the presence of these travel inhomogeneities. A key result of practical significance, the set of candidate points for optimal facilities, is shown in both cases to be reduced to a finite set of points.

Research also continued to be carried out in the area of "dial-a-ride" urban vehicular systems. Advanced mathematical procedures were developed for routing a single vehicle in a dial-a-ride situation having many locations for customers and many different destinations. Other algorithmic advances were also obtained, both mathematically optimal and mathematically near-optimal (heuristic), for routing the dial-a-ride vehicle or vehicles.

Applications of operations research techniques to spatially distributed stochastic systems was not limited to the urban environment, but considerable effort was focused on emergency responses to oil spills at sea. Questions of optimal routing, location, and scheduling of events occur for these problems as well as for more usual problems that occur in an urban environment. Extensive research was successfully undertaken in the oil spill analysis area during this year, leading to a comprehensive computer-based model for addressing the entire problem.

Work continued in the energy modeling area. One effort focused on a comparative study of coal supply and demand modeling, using spatial equilibrium models as the integrating mechanism. In addition implementation of an energy sector model for evaluating new energy techniques that incorporate endogenous energy demands was completed.

Research progressed in developing planning models for mental health care systems, some of the work being done in conjunction with local facilities in the Cambridge/Somerville area. The work is concerned with the application of operations research techniques to aid planning in mental health systems, particularly in light of the ongoing deinstitutionalization process. During the past year a paper was completed that reports the development and application of a queueing model for facilities planning.

Work continued this year in the area of designing new methods for evaluating public programs. Under a research program entitled "Adaptive Evaluation Designs," research has progressed in designing strategies for obtaining information in a sequential, dynamic, and adaptive manner from ongoing public programs in a way which maximizes the decision utility of the ultimate evaluation within the fixed time and budget constraints of the evaluation itself. The approach is compatible with so-called decision-oriented approaches to program evaluation, and utilizes deductive mathematical models, statistical inference, and other techniques common to operations research.

Some applied work of considerable significance has occurred this year in the area of traffic light synchronization. ORC faculty have been attempting to transfer some of their latest methodological advances in integer programming decomposition to this problem. The basic idea is to develop algorithmic techniques for determining the cycle times, red and green splits, and interrelated phase times of the various traffic lights in an arbitrary two-way street urban traffic network. Over the years, the ORC has made substantial progress on this problem.

Private-Sector Research

During the past year ORC faculty and students continued their deep commitment to research in operations management, corporate planning, and other decision problems of the private sector.

Research progressed in the application of operations research methods and models, especially mathematical programming, to research management problems arising in corporate planning. One project involved the design and implementation of a paper mill scheduling system called CYCLIST. CYCLIST has interactive programs for permitting the user to describe mill operating conditions and an orders policy for short-term planning horizons of one week to two months. This information is used to create a model which is then optimized (according to time and/or cost) using a heuristic-based nonlinear program. CYCLIST has been successfully implemented for two paper mills with associated time savings of two percent or more. Additional significant progress was made in applying physical logisitics and financial planning models to multinational corporations and a consumer products company.

An extensive amount of work occurred this year in the area of operations management and production planning. A considerable fraction of this work was in the area of hierarchical production planning systems. This entailed the design of model-based production planning systems following a hierarchical approach, with either one-stage or two-stage hierarchical structures. Related work took place in inventory planning and control, including the problem of setting safety stock levels in a multi-stage production system and the development of a planning-scheduling model, with a control of work-in-progress inventory for an integrated circuit manufacturing process. Additional related work took place in the design and planning of logistics systems related to manufacturing, including the control of repairable item inventories. Further production planning research occurred in the area of spare parts inventorying, scheduling rules for open and closed job shops with fabrication and assembly operations, and production planning problems in large corporations.

Additional private-sector research has occurred in several applications of advanced mathematical optimization techniques, as detailed in the next section.

Mathematical Optimization

ORC faculty continued their nationally recognized research into problems of mathematical optimization subject to constraints. This active research area, sometimes known as mathematical programming, has involved both theoretical and applied contributions.

During the past year, ORC faculty have continued the study of new parametric methods for mixed integer programming problems using inverse optimization. Inverse optimization refers to the following result of Lagrangean relaxation applied to any mathematical programming problem. Each Lagrangean calculation produces an optimal solution to a mathematical programming problem with the right hand sides suitably adjusted. ORC faculty have studied the application of the Lagrangean result to production distribution and planning problems, warehouse location, and tanker scheduling. The approach is considerably enhanced by integrating it with approximation methods. Some promising computational results have already been obtained using subgradient optimization, and experiments are beginning with a primal-dual method which is expected to be more stable. Inverse optimization is particularly well suited to computation on microprocessors, since subgradient optimization does not require matrix inversions.

A major research thrust occurred this year in the area of network analysis and optimization. The overall work focuses on three separate but related topics: 1) the effects of model formulation on integer programming decomposition; 2) heuristic analysis of combinatorial network problems; and 3) analysis and modeling of network equilibrium problems (e.g., traffic equilibrium and energy distribution). This past year the focus has been on network design problems, large-scale Euclidean location problems, traffic equilibrium problems, and a general linear activity equilibrium model.

Considerable research has occurred this past year in two areas related to solving difficult scheduling problems via computer techniques. The first question is, "When is a given problem class inherently difficult to solve?" The second question is, "How can one effectively solve problems that are probably too difficult to solve?" The first type of question is motivated in part by dynamic/periodic systems which arise in transportation (e.g., airplane scheduling) and in personnel scheduling (e.g., the scheduling of a work force so as to meet a complicated set of regulations, requests, and obligations). Some work in the area is considerably more complex at the theoretical level involving something known as the "matroid parody problem," a problem which could contribute significantly to our understanding of a number of problems of operations research and combinatorial optimization. The second question is being addressed by analyzing alternative approximation schemes to inherently complex problems. The objective is to determine solutions that are required to be "almost" optimal. Rates of convergence to optimality are considered in the research.

Work has continued in the development of a descriptive modeling language for mathematical programming models. On the one hand, new applications of the language to planning problems in agribusiness, consumer products, and the computer industry have resulted in improvements. Specialized user-friendly input programs have been designed and implemented for planning problems in these areas. On the other hand, the generation program, which reads the language specification of a model and creates the appropriate files, has been improved so that it creates better mixed integer programming formulations. The generation program also passes information about the problem it creates to the optimizing program regarding promising branch and bound strategies.

New work has commenced in mathematical programming in the area of "aggregation, approximation, and decomposition." The central idea is that for most planning problems, there is considerable leeway in the choice of a mathematical programming model to represent the problem, and in how the model can be solved. For example, some aggregation of products and consumers is inevitable in developing large-scale production distribution models. Very little research has been directed at trying to evaluate the "best" level of aggregation, taking into account data errors and the degree of accuracy desired by the decision maker. Aggregation is clearly a model approximation method designed to ease computation, but there are other approximation methods possible, including inexact optimization of the model. Again, we could ask what is the "best" level of approximation to be used in generating and optimizing a specific model. Decomposition methods are well-suited to studying and answering these questions. Principles of aggregation, approximation, and decomposition can be readily implemented into the model generation program discussed earlier since the descriptive modeling language can be readily adapted to allow flexible model generation and optimization.

Educational Programs and Activities

The ORC offers interdepartmental programs at both the master's and doctoral levels. The S.M. program generally consists of four core courses plus three elective graduate-level subjects, followed by a master's thesis. Graduates of the S.M. program are well grounded in the theory of operations research and its application to public- and private-sector problems. Graduates typically become members of technical staffs of private firms, planners in government agencies, or private consultants. During a typical year, there are approximately 20 MIT graduate students who are pursuing the OR S.M. degree, and since the program requires about two years to complete, about 10 are graduated each year. The year 1981-82 was no exception, with 11 OR S.M. degrees being awarded.

The doctoral program in operations research provides a strong background in the theoretical foundations of OR and the techniques used to develop and analyze mathematical models of complex systems arising in economic, social, and physical contexts. Most graduates of the program have assumed faculty positions in the US and abroad. The program generally consists of seven core courses, course work in a minor concentration, and dissertation research culminating in a thesis detailing original and creative research under the guidance of a thesis committee. During 1981-82, four Ph.D.s were granted in Operations Research. There were 22 students enrolled in the program at various stages of completion of their Ph.D. degrees.

The ORC also sponsored five courses offered through the Summer Session Office. One of the courses was Public Policy Evaluation, taught by Richard C. Larson, professor of Electrical Engineering and Urban Studies, and co-director of the Operations Research Center, and Martin Rein, professor of Urban Studies. Energy Planning Models was taught by Jeremy F. Shapiro, professor of Operations Research and Management at the Sloan School of Management and co-director of the ORC in conjunction with Professor Eduardo M. Modiano from the Economics Department of Catholic University of Rio de Janeiro and a graduate of MIT in operations research. In addition, Professor Shapiro offered Resource Management: A New Approach to Corporate Planning with the assistance of Paul S. Bender, director of Resource Allocation Systems at the International Paper Company, and William D. Northup, a research associate in the Center for Computational Research in Ecomonics and Management Science at MIT. Two one-week courses were presented in decision analysis, taught jointly by Alvin W. Drake, professor of Systems Science and Engineering, and Dr. Ralph L. Keeney, senior researcher at Woodward-Clyde Consultants Associates in San Francisco. The two courses were entitled Decision Analysis Concepts and Applications and Decision Analysis with Multiple Objectives.

The ORC seminar series is organized each year by two doctoral student coordinators, and invited guest speakers make presentations on topics of interest to the graduate students and staff each week during the academic year. During 1981-82, Panos Constantopoulos and John VandeVate coordinated the program. The ORC was fortunate to have as its initial speaker of the year Professor Jack Edmonds of the University of Waterloo. His presentation was entitled Linear Programming and Combinatorial Topology of Sphere Systems. Among other distinguished speakers from both within and outside the Institute were Joe F. Moore, president of Bonner & Moore Associates, Inc.; John D.C. Little, professor in the Sloan School of Management, and Christos Papadimitriou, professor of Electrical Engineering and Computer Science at MIT.

ORSA Student Chapter

During the spring term 1982, the students at the ORC initiated steps to form an MIT student chapter of the Operations Research Society of America (ORSA). The primary objectives of the chapter are 1) to encourage interest in the professional field of operations research; 2) to provide an informal means of exchanging information about the methods and applications of operations research; and 3) to promote interaction with other ORSA student chapters. A committee of three students drafted a constitution which will be submitted for approval at the next ORSA meeting, after which the chapter will be formally launched. The membership will be open to all MIT students.

Visiting Scholars

The ORC was able to extend its facilities to several visiting scientists who advanced their research at MIT. Dr. Shan Cretin, a graduate of the Operations Research Ph.D. program and currently assistant professor in the School of Public Health at UCLA, spent her sabbatical at the ORC, collaborating at the Whitaker College of Health Sciences, Technology, and Management and the Harvard School of Public Health. Her research involved developing OR models in health policy analysis and clinical medicine. Dr. Sukho Kang, associate professor in the College of Engineering at Seoul National University, Korea, was involved in research on production planning and control at the ORC, partially funded by an IBRD grant to allow Korean faculty an opportunity for research involvement in the US. Professor Mihai Marsanu had a one-month visiting appointment at the ORC funded by the International Research and Exchanges Board (IREX) as part of a multi-university tour. Professor Marsanu is the head of the research laboratory of the Research Institute for Computer Techniques in Bucharest, Rumania. Dr. Samuel S. Chiu, a recent graduate of the Operations Research Ph.D. program, also had a brief visiting scientist appointment at the ORC to continue his research on the integration of queueing phenomena in locational decision making. He goes on to an appointment as assistant professor of Engineering-Economic Systems at Stanford University.

Administration

The ORC took on a new face this year, moving its office headquarters from Building 24 to the newly renovated Building E40 in February 1982. Accompanying the change in office space was an increase in office administrative help from part-time to full-time support, in anticipation of greater research and academic activity within the ORC.

RICHARD C. LARSON
JEREMY F. SHAPIRO

Project STILE

Under the auspices of Institute Seminars 211 and 212, local opportunities are available for students to become involved in a wide range of educational action, research, and/or community service activities as well as obtaining Massachusetts Teacher Certification. Research and service opportunities

are available through Project STILE (Student-Teacher Interactive Learning Environment) and Upward Bound, and are sponsored by the Seminars. Massachusetts Teacher Certification is offered to students through a joint program with Wellesley College.

Project STILE, drawing from the experience of its staff with the MIT/Wellesley Upward Bound Program and based on 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 was developed at the Institute by MIT staff and Cambridge public school teachers in 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 with the class, 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 teacher-student 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 lead to students dropping out of school. STILE, which was validated as an exemplary educational program by the Massachusetts Department of Education, offers ways of breaking this cycle by raising teacher expectations for all students.

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 the population was predominately lower-socioeconomic. With this grant, STILE added parent workshops, modeled closely after teacher workshops, in an effort to bridge the gap between home and school. The purpose of the workshops 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.

During this past year, STILE was able to place parent-teacher teams in Cambridge elementary schools; the teams worked to support high expectations in the classroom and to encourage communication between teachers and the parents of students in their classrooms.

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. MIT has been asked to play a larger role in the certification process under a newly negotiated program approved this past year by the Massachusetts Department of Education. As a part of this program, Upward Bound has become a pre-practicum site for those seeking teacher certification.

JOHN P. TERRY

ROTC Programs

The Reserve Officer Training Corps (ROTC) programs at MIT continued to provide a set of unique educational, leadership, and financial aid opportunities for our students. The quality and vitality of the programs remained at the high level noted in last year's report. The interest, commitment, and enthusiasm of participating students appeared to be at similarly high levels. On a national level, ROTC programs experienced renewed levels of attention from students, university administrators, and the news media. This increased attention derived apparently from both changing attitudes toward military service and concerns over possible reductions in other forms of student financial aid.

Given all of these favorable local and national factors, it is at first suprising to note that total enrollment in MIT's ROTC programs declined for the first time in several years. However, a portion of the decline is accounted for by termination of our cross-enrollment arrangement with Northeastern University in the Air Force ROTC program. In fact, enrollment of MIT students in the Air Force program actually showed a small increase. Enrollment in the Navy unit benefitted from newly established cross-enrollment arrangements with Harvard and Tufts University and a special, temporary arrangement with Boston University, but it still showed a small decline. The major enrollment decline was in the Army program, where the number of cross-enrolled students dropped by 30, and MIT student participants dropped by 31.

Enrollment in the three ROTC programs at MIT in the fall of 1981 was as follows:

SERVICE	YEAR	I	II	III	IV	TOTALS
Army		19	25	27	22	93*
Navy		52	28	23	18	121**
Air Force		100	73	27	36	236***
	TOTALS	171	126	77	76	450

*Includes 39 students cross-enrolled from Harvard University (19), Tufts University (16), and Wellesley College (4).

**Includes 11 students cross-enrolled from Boston University (3) and Harvard University (8).

***Includes 58 students cross-enrolled from Harvard University (33), Northeastern University (2), Tufts University (18), and Wellesley College (5).

Fifty-one seniors, including 41 MIT students, were commissioned on May 31, in a tri-service exercise held at the USS Constitution National Historical Site. Guest speaker for the commissioning was Admiral L.J. Long, CINCPAC, who made the actual presentation of commissions on board the USS Constitution.

During the year several other tri-service events were conducted, including a military ball, field day, awards banquet, parade and pass-in-review, and an Armed Forces Day reception for the MIT community. These and other joint activities reflect the healthy spirit of cooperation that exists among the three services at MIT.

The ROTC Faculty Advisory Committee, under the chairmanship of Professor David K. Roylance, continued to monitor the ROTC program and to evaluate prospective military ROTC instructors.

The three detachment commanders--Lieutenant Colonel George S. Smith, Jr. (Army), Captain David V. Burke, Jr. (Navy), and Colonel Joel S. Hetland (Air Force) -- each completed their first year of service at MIT.

FRANK E. PERKINS

Sea Grant College Program

The Sea Grant Program was created in 1966 to accelerate the national development of marine resources with appropriate caution to preserve the resource base for future generations. MIT became part of Sea Grant in 1968 when the Institute was given the Program's first grant to develop five ocean engineering textbooks. In 1976 MIT achieved another milestone when it was the first private university to be designated a Sea Grant College in honor of its excellence in research,

education, and advisory services. During the ensuing years, MIT's Program has continued to move toward greater challenges and deliver benefits to the Institute, the state, and the nation.

In the fall of 1981, Dean A. Horn announced his plan to retire as director of Sea Grant after 12 years of helping to manage the Program. Mr. Horn had served as executive officer from 1970 and was appointed director in 1976. He will be succeeded by Professor Chryssostomos Chryssostomidis of the Department of Ocean Engineering on July 1, 1982. The remainder of the management staff will continue in their duties. Keith D. Stolzenbach of the Department of Civil Engineering and Anthony J. Sinskey of the Department of Nutrition and Food Science will act as associate directors of research coordination. The associate director of education and training will be E. Ray Pariser, senior lecturer in the Department of Nutrition and Food Science. Sea Grant's advisory services will be led by Norman A. Doelling, Arthur B. Clifton, and Elizabeth T. Harding. Mr. Doelling will also serve as the Program's executive officer beginning on July 1, 1982. Lawrence W. McKinnon will serve as administrative officer.

Research

Sea Grant's research thrusts are concentrated within a few key thematic areas. This concentration helps to focus Sea Grant's resources and define current interests. Those themes are: Unmanned Underwater Work Vehicles, Offshore Facilities, Coastal Processes, Living Resource Utilization, and Technology Development and Management for Ocean Uses.

This past year Sea Grant administered 26 projects with the participation of 12 MIT departments, laboratories, and centers, and 31 faculty members. Students and faculty have made MIT the leader in ocean engineering. This has been important as the nation has moved seaward off the continental shelves for new discoveries of oil, gas, and minerals. Several projects in the Departments of Ocean and Mechanical Engineering have helped pioneer robotics for undersea exploration and development. Soil mechanics studies in the Department of Civil Engineering aim at safer, more efficient offshore construction and maintenance. The *Alexander L. Kielland* and *Ocean Ranger* accidents in deep, stormy waters have proven the need for improvements in offshore design and operation. Ocean engineers at MIT are looking carefully at new design techniques for mooring cables and platform risers and at better underwater welding methods.

MIT, the nation's first school of naval architecture, still contributes research for maritime industries. Projects sponsored within the Sea Grant Program were concerned with improving ship energy efficiency through decreased wave resistance, strengthening design criteria for vessels maneuvering through ice, and helping to find better methods for cleaning up oil spilled near shore. A multidisciplinary project in the Departments of Mechanical Engineering and Materials Science and Engineering has been looking for ways to stop rope deterioration.

Coastal waters offer a different kind of research challenge than the offshore environment. Studies of ecosystems are necessary for making intelligent decisions that govern commonly owned resources. Oceans move with the tide, wind, and waves, erasing boundaries between locales and industrial uses. Sea Grant projects this past year included research into mitigating the harmful effect of employing the oceans for waste disposal. One effort helped engineer outfalls for adequately dispersing brine from oil storage caverns into productive fishing grounds in the Gulf of Mexico, and another investigated the use of biotechnology for extracting contaminants from industrial wastewater. Careful scrutiny in tidal marshes could eventually lead to the use of wastes for nourishing fish farmed in wetlands. In Sea Grant's view, fish resources offer not only valuable and healthful food, but useful by-products as well. Research in the Department of Nutrition and Food Science looked at shark cartilage as an inhibitor of vascularization within tumor tissue. Continuing research into chitin, a waste product from shellfish processing, could yield a matrix for the manufacture of specially engineered foods and a capsule for housing fish larvae feed.

These short descriptions are a sampling of the projects Sea Grant sponsored last year and only hint at the truly exciting marine research being conducted at MIT.

Education

Sea Grant's educational objectives are multifaceted. They seek to train young men and women in scientific and engineering disciplines for careers in industry, government, and academia. For

undergraduates the Program supports an interdisciplinary design class and several UROP projects. Graduate students participate directly as contributors to all Sea Grant sponsored research. Through conferences, special courses, and publications, professionals in marine-related jobs can keep abreast of the latest technologies and the information resources available through the nation's universities. This past March Mr. Pariser and Dr. Sinskey organized the first major conference on applying new techniques from biotechnology and genetic engineering to the marine sciences. More than 100 participants heard prepared papers, exchanged views on the research potential for aquaculture, marine pollution, biofouling, and bioproducts. The proceedings to be published in the fall of 1982 are expected to have a significant impact in bringing together industry and academic interests to undertake promising scientific studies.

Part of Sea Grant's mission is also to educate the public on the importance of water to the planet and the ways it can be used and abused. The ultimate aim is an understanding that will lead to wise utilization and management of the resource. A set of integrated, progressive teaching modules for grades kindergarten through eight were completed in the past year. And again MIT was in a leadership position. When the Commonwealth of Massachusetts validated these teaching tools for statewide use, they became the first educational materials in the Sea Grant network to gain this kind of credential. Mr. Pariser organized an MIT advisory committee to help conceive and execute a television series of eight programs on the "World of Water." The series, which has captured the interest of several well-known producers and a public television station, would make millions of people aware of the many roles water plays in their lives.

Advisory Services

Advisory services also aid in the educational objectives of the Program. The Massachusetts Marine Liaison Service (MMLS), headed by Mr. Clifton, continued to offer special courses for New England's fishing industry in cooperation with the Massachusetts Maritime Academy. This past year Mr. Clifton and his staff established a new partnership with the David W. Taylor Naval Ship Research and Development Center (DTMB). DTMB has offered their circulating water channel for fishing gear research. The facility will be accessible to MIT, other Sea Grant programs, and industry or government engineers through MMLS.

Sea Grant's Marine Industry Advisory Service (MIDAS) is managed by Mr. Doelling to bring industry, academic, and government marine interests together for germinating new ideas, solving existing problems, and sharing expertise. MIDAS publishes a newsletter, *Research in Ocean Engineering: University Sources and Resources*, which in 1982 became partially self-supporting through a subscription fee. Five workshops were held, three at MIT and two in Houston. They included: Offshore Geotechnical Evaluation, Vertical Seismic Profiling, Directions for MIT Research in Unmanned Underwater Work Systems, Dynamics of Marine Risers, Cables and Moorings, and the Biotechnology in the Marine Science conference organized by Sea Grant's educational unit.

The Communications/Information Office continued its newsletter, the *MIT Sea Grant Quarterly Report*. A report series, which was established in 1970 to disseminate the information on the Program's research results, included 15 publications this year. The Sea Grant Marine Information Center, a small reference facility open to the MIT community and the general public, published its eighth annual directory of all MIT marine-related research. In cooperation with the Department of Ocean Engineering, the Communications/Information Office edited and published the proceedings from the First Bruce Wallace Lecture, an analysis of the *Alexander L. Kielland* offshore platform accident in the North Sea.

It seems apparent at this time that Sea Grant, like other Federally sponsored programs, will be operating under budget constraints and pursuing other sources of funding. Although this will tax researchers and staff alike, the result could be strengthened and productive relations with American industry, the principal group which has the capability for putting the oceans to work.

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.

The total registration of 1,887 in the 1981 program was almost identical to the registrations of 1,888 in 1979 and 1,893 in 1980. No three consecutive years have ever been so similar.

Noteworthy trends in recent years are the increasing numbers of women registrants and of applications from Mexico.

Regular Subjects

Graduate students comprise 80 percent of the student body in summer. The 1981 registration of 2,364 students was a minor decrease from the 2,397 in 1980.

JAMES M. AUSTIN

Technology Adaptation Program

The Technology Adaptation Program (TAP) is an interdisciplinary research program with a primary objective of promoting an awareness on the part of faculty and students at MIT, as well as foreign students and scholars who attend MIT of the technological problems facing developing countries. 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 masters 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 (who is also 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:

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

2) The TAP Policy Committee is chaired by Professor Nazli Choucri of the Department of Political Science (who is also associate director of the Program). Members are Professors Moavenzadeh, Daniel M. Holland of the Sloan School of Management, and Jack P. Ruina of the Department of Electrical Engineering.

3) TAP Advisory Committee, composed of the Deans of the Schools, Professors Choucri and Moavenzadeh, and chaired by the Provost, is responsible for overseeing TAP activities and advising on Institute policies and administrative procedures.

Jeanne De Pass is the Program's administrative officer and Kevin J. O'Toole serves as technical officer. Robert P. Greene serves as the MIT/TAP representative in Cairo.

TECHNOLOGICAL PLANNING PROGRAM IN EGYPT

In January 1977, TAP entered into an agreement with Cairo University to establish a collaborative program focused on science, technology, and development. This program, which has been funded by the US Agency for International Development, has as its principal objective the development of capabilities within Cairo University to contribute to the formulation and implementation of science- and technology-related policies designed to assist Egypt's development goals. To this end, three specific objectives have been pursued: 1) mobilization of academic interest in research on specific development plans; 2) organization of technical research in collaboration with Egyptian government ministries; and 3) establishment of an institutional framework under Cairo University auspices capable of mobilizing research and educational activities of Cairo University faculty, staff, and students.

To achieve these objectives, a series of activities was initiated, including:

- A set of collaborative research projects among faculty members of Cairo University, MIT, and representatives of appropriate government agencies and ministries in Egypt focused on the development needs of Egypt.

- Educational exchange opportunitites through which Egyptian participants would come to MIT for special research-related instruction as well as for degree-granting programs.

- Mini-research projects designed to encourage the participation of Cairo University faculty in research for both the public and private sectors.

- Fellowship programs at the postdoctoral and doctoral level for faculty and graduate students of Cairo University, which would encourage participation in development-related projects in Egypt.

- Industrial internships to provide Cairo University faculty with an opportunity to become familiar with the operations of government ministries and public enterprises.

- A series of conferences, workshops, seminars, and short courses focused on program research activities and findings.

- The establishment of the Development Research and Technological Planning Center at Cairo University to provide a permanent institutional mechanism for sponsored research and educational activities.

The development and conduct of these activities were predicated upon employment of three general analytic approaches: 1) engineering analysis and technical project evaluation, addressing specific technical issues, including field and laboratory studies, design, and training requirements; 2) economic analysis, focusing on project sector and national planning issues, and micro- and macroeconomic studies related to specific Egyptian development programs; and 3) social science analysis of population and labor-force issues, socioeconomic change including urbanization, extension of social services, and technology transfer strategies.

Since 1977, 19 collaborative projects have been developed between MIT faculty members, their counterparts at Cairo University, and the appropriate ministry or government agencies in Egypt. The projects focus on a broad range of engineering, economic, and social science topics. The key element in each of these efforts is the interdisciplinary team drawn from faculty and staff from Cairo University, MIT, and government ministry personnel responsible for development of research projects oriented toward the national development needs of Egypt.

Development-oriented research serves several objectives at Cairo University including a) developing national capabilities in the field of science, technology, and development; b) providing a vehicle for education of future generations of engineers and scientists; and c) allowing for substantial increase in the volume of contract research.

The thrust of the program and its dedication to the advancement of current Egyptian development programs have created a strong desire on the part of Cairo University faculty for an opportunity to participate in the program, and for the Cairo University administration to lend its strong support and cooperation. The research projects, educational opportunities provided by conferences, workshops, and short courses, and fellowship programs have upgraded the technical capabilities of the faculty and graduate students, and developed a nucleus of individuals who have an awareness of and interest in the contributions which can be made by the academic community in achieving the development goals of the Egyptian government. The professional ties and relationships established with MIT faculty, Egyptian ministry personnel, and officials of international organizations have proven to be solid and long lasting.

RESEARCH PROJECTS OF THE TECHNOLOGICAL PLANNING PROGRAM IN EGYPT

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 Professor Martin Weitzman (Department of Economics) and Professor 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.

Energetics in the Egyptian Metal Industries. The objective of this project is to study and recommend methods of bringing about near-term and long-term improvements in the aluminum and iron-and-steel industries. The project is under the direction of Professor David Gordon Wilson (Department of Mechanical Engineering).

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 application for plastics materials. The project is under the direction of Professor Frederick McGarry (Department of Materials Science and Engineering).

Production Planning Methodology for the Egyptian Automotive Industries. The objective here is to design a new system to plan and control assembly, fabrication, and procurement in the Industrial Vehicle Division at El Nasr Company. The project is under the direction of Professor Gabriel R. Bitran (Sloan School of Management).

Public Works

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 intercity 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 Markow, Brian Bradmeyer, Morteza Salehi and Frederick Salvucci in the Department of Civil Engineering are contributing 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 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 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 Marks (Department of Civil Engineering).

Energy and Environmental Impact Studies for the Quattara Depression Project. The objective of this project is to develop mathematical models to predict the time variation in water level and salinity of the future Quattara Lake. This project is under the direction of Professor Donald R.F. Harleman (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 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). Professor Amr Azzouz of the same department is also contributing to this project.

Infrastructure for Secondary Cities in Egypt. The objective of this project is to study methods whereby the use of infrastructure can improve urban land development patterns. The project is under the direction of Professor Ralph Gakenheimer (Department of Urban Studies and Planning).

Socioeconomic Development

Communication 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).

DEVELOPMENT RESEARCH AND TECHNOLOGICAL PLANNING CENTER AT CAIRO UNIVERSITY

The concept of establishing a permanent institution, to foster and encourage research by Cairo University faculty and students on topics relevant to the developmental objectives of Egypt, was an outgrowth of the successful experience of the collaborative effort between Cairo University and MIT in the Technological Planning Program. In order to sustain these efforts, Cairo University established in 1979 the Development Research and Technological Planning Center (DRTPC) as an autonomous research unit, and provided it with more than 2500 square meters of space in a new building on the campus. The Center is currently providing an institutional mechanism at Cairo University for conducting contract research in the area of science, technology, and development.

The following general guidelines have been established concerning the Center's objectives and organizational structure:

- The principal activity of the DRTPC will be research. The Center will emphasize sponsored research programs with specific objectives.

- The research will focus on those areas of science, technology, and development which address the development goals of the government of Egypt. This research will not duplicate the work of other research units at Cairo University or other government agencies.

- The Center's educational activities will concentrate on fellowships, short courses, and workshops which support the training of research personnel at universities and government ministries, as opposed to the granting of academic degrees.

- The Center will establish effective mechanisms for utilizing Cairo University faculty and the faculty from other Egyptian universities in its research programs, and does not plan to develop a permanent research staff.

- The quality of the research will be monitored by appropriate faculty committees, to ensure compliance with the standards and objectives of the Center.

The organizational development strategy for the Center has focused on three major elements: policy making, administrative infrastructure, and research and education operations.

The Center's primary policy-making unit consists of a board of directors and a director, appointed by the Rector of Cairo University. The board of directors constitutes the major policy-making authority, and its responsibilities include approval of specific research areas, formulation of general development policies, review of administrative guidelines, review of proposals for outside contracts and grants, and approval of project and administrative budgets. The director is responsible for implementing the decisions of the board of directors and for coordination of all resources utilized by the Center.

The Cairo University/MIT Technological Planning Program Liaison Office has served as a model for the administration and financial control system for the Center, and it is currently being integrated into the administrative structure of the Center.

A Center library has been established and is developing a collection which includes: 1) all publications of the DRTPC, and working papers, theses, and journal articles related to DRTPC activities; 2) a basic reference collection of statistical information on Egypt, as well as other important reference sources on science, technology, and development; and 3) reference works pertinent to research currently under way at the DRTPC.

A computer system capable of supporting 20 to 30 simultaneous users has been purchased and installed at the Center to support the following activities: 1) general computational support for the research programs; and 2) administrative, financial, and accounting operations, as well as other management information systems. A computerized search and retrieval system will also be installed to reference the holdings of the DRTPC library.

To provide continuity in funding for the Center, four major sources of funding have been identified and are being pursued by the administrators of the Center, as follows: 1) grants by Egyptian

government organizations for general training and administrative activities, 2) grants from Egyptian government organizations for research and technical assistance programs, 3) direct research contracts with Egyptian and foreign institutions, and 4) grants or endowments from international organizations.

The Center currently has 32 research projects under way (including those of the CU/MIT program), with sponsorship from 12 different Egyptian, US and international institutions.

Dr. Mohamed El-Hawary was appointed as the director of the Center in April 1982. The Center's board of directors consists of Dr. Hassan Hamdi Ibrahim, chairman; Dr. Mohamed Zaki Shafei, professor of Economics; Dr. Hassan Ismail, professor of Hydraulics and Irrigation; Dr. Salah Shahbender, professor of Surgery; and Dr. Ahmed Ebada Sarhan, professor of Statistics. The government of Egypt is represented by the Ministers of Electricity and of Planning.

Following a joint committee at MIT in April, the Egyptian board of directors visited Agency for International Development (AID) administrators in Washington, DC to report on the successes which have been achieved through the program. During their meeting with Antoinette Ford, assistant administrator, Bureau for the Near East, they were assured of continuing support for the Program beyond the present contract date.

EDUCATIONAL OPPORTUNITIES

TAP has expanded educational opportunities both at MIT and in Egypt. Opportunities for learning have been made available to both faculty and students interested in general or specific topics related to transfer and adaptation of technology, and valuable experience on specific, real problems has been gained. The projects have provided an opportunity for future decisionmakers 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, 147 research assistantships have been in effect. Twenty-eight theses (10 at the Ph.D. level) have resulted from these assistantships, with an additional 39 in progress (21 at the Ph.D. level).

Master's Degree Program at MIT

TAP provides educational and research opportunities for master's candidates who are interested in the transfer and adaptation of the technologies of their own areas of specialization to the needs of developing countries. Students who elect this opportunity devise an educational program which includes those subjects required for their chosen area of concentration, and at least one subject which deals with management techniques of special importance to developing countries, one graduate subject in Economics which is related to developing countries, one subject in the social sciences area which deals with structures required to support the applications of technologies, and one subject in an engineering area related to the transfer or adaptation of new technologies in developing countries. Fourteen students this past year received financial support in the form of research assistantships associated with current TAP research projects.

Visits by Foreign Scholars

To date, more than 178 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.

The Program also had visits by scholars from Germany, Algeria, Pakistan, and Venezuela who presented seminars and shared their experiences with MIT colleagues.

Conferences, Workshops and Seminars

Each year the program conducts a major conference in Cairo. January 1982 marked the fifth anniversary of the program. MIT Chairman Howard W. Johnson led a delegation of MIT Corporation Executive Committee members to Egypt to participate in a symposium in observance of the fifth anniversary. Members of the Corporation who particiapted were Edward R. Kane, Breene M. Kerr, William B. Murphy, D. Reid Weedon, Louis W. Cabot, Emily V. Wade, and Constantine B. Simonides, secretary to the Committee. The symposium provided an opportunity for respresentatives of Cairo University, MIT, the government of Egypt, and the US Agency for International Development to report on the effectiveness of the program in terms of manpower development, research utilization, and education value of the collaborative efforts. In addition to Dr. Johnson, presentations were made by five government ministers, the US Ambassador to Egypt, and the Mission Director of US Aid to Egypt.

Following the symposium, a two-day technical conference was held. More than 20 MIT faculty and students participated in these sessions to report on the technical accomplishments of their projects. Three of the research teams conducted workshops in Cairo during this year. These workshops were held in the following areas: communications needs for rural development, analysis of water resource systems, and plastic piping for potable water supply.

OTHER ACTIVITIES OF TAP

In addition to the Cairo University collaborative conferences, TAP also sponsored a conference at MIT in conjunction with the United Nations Fund for Population Activities. More than 25 people participated in thi s conference.

In November 1981, discussions were held with the president of the Technical University of Berlin to explore the possibilities of developing a collaborative arrangement between the two institutions with a focus on a third developing country. It was agreed that the international interest and research capabilities of the two universities were complementary, and that a joint program could be of great value. A workshop has been arranged for September 1982 to discuss the specific details of the collaborative arrangement.

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.

Administrative Support

In supporting the institutionalization effort of the Center at Cairo University, MIT administrators have visited Cairo to work with the Egyptian managers. James Culliton, director of Personnel, provided invaluable assistance in the preparation of an organizational plan for the Center's development. This plan will be used to initiate the organizational growth, staffing and compensation patterns, and personnel policies. George Dummer, director of the Office of Sponsored Programs and Philip Keohan, comptroller of Financial Operations have been to Cairo and, with their staffs, are assisting in the establishment of accounting systems and contract management procedures for the Center. This effort will be of a continuing nature.

Publications

TAP publishes its own series of technical reports in addition to those papers which are included in the broader area of the principal investigator's technical journals. Since the start of the Egyptian project, more than 300 papers and reports have been published.

FRED MOAVENZADEH

Undergraduate Research Opportunities Program

A review of the past 12 months reveals two broad headings under which many aspects of our most recent history may be categorized. First is the outside interest which seems to grow each year in the Undergraduate Research Opportunities Program (UROP) as a program, and in UROP students as individual achievers. The second, maintaining financial support for student endeavors, reflects the pressures and uncertainties of our wider context.

Two undergraduate participants, Richard Auchus, Class of 1982, and Anne Ko, Class of 1983, were in the limelight on October 30th, along with Professors Robert Langer of the Department of Nutrition and Food Science and John Edmond of the Department of Earth and Planetary Sciences. They were invited by the MIT Resource Development Office to speak about their UROP involvement before the annual meeting of the MIT Corporation Development Committee. This marked the first occasion for UROP undergraduates to address this Committee. This year there were several regional MIT club invitations: Ray Goldstein, Class of 1983, and Mr. Auchus were invited to talk to the Northern New Jersey Alumni Club; and students and UROP staff were invited to two other alumni meetings: Assistant Director Clifford Truesdell, traveled with Jonathan Cohen, Class of 1982, and Lisa Wilson, Class of 1983, to New Haven, CT; and Associate Director Norma McGavern, went with Mr. Goldstein and Vicki Schreer, Class of 1982, to the Springfield, MA area alumni club. The UROP staff works intensively with student speakers before such events, which are often the student's first brush with public speaking.

Interest in UROP came from many areas in addition to alumni. A film crew from public television station WGBH in Boston (which airs the Nova science series) has been following and filming the college plans of four high-school students who were winners of Westinghouse talent search scholarships, and they visited MIT in May to follow one of these students as she explored the possibilities of UROP, which was a key factor in her decision for choosing MIT. Professor Robert Mann served as UROP guide and host in the Biomechanics and Human Rehabilitation Laboratory, where most of the filming was done. The program developed from this filming will be shown sometime during the winter of 1982-83 with the probable title, "Young Scientists."

MIT also received a request from the US Department of Education, specifically from the National Commission on Excellence in Education, inviting us to profile the history, motivating forces, goals, and achievements of UROP as one of approximately 35 programs chosen by the Commission as national models of excellence. One consequence of our report to the Commission was a further request that UROP's director, Professor Margaret MacVicar, testify in June at one of six national Commission hearings.

Communication with other colleges and universities continues in regard to the establishment of programs generically related to UROP. Extensive consultation with Brown University early this year was aimed at helping that institution evaluate its undergraduate internship program. Other universities keep us abreast of programs they have established, based directly on MIT's UROP: e.g., Imperial College (London), the University of Delaware, Brandeis University, Stanford University, Harvard University, Utah State University, and Johns Hopkins University.

The Financial Aid Office has reported that the large and rapid increases in MIT tuition have resulted in greater student need for wages throughout the Institute. However, the term-time ratio of academic credit to wages as reward for UROP activity still remains approximately the same as previous years. We forsee pressures this fall, though, that might drive the current ratio, tilted in favor of credit, toward a weighting for pay. The number of students participating

was higher this spring than ever before (16 percent higher than spring 1981, 25 percent higher than spring of 1979), and demands for summer 1982 funding were very strong. We have looked squarely at the possibility of an undergraduate research wage increase, and have come to the conclusion that we will continue our present hourly wage rate of $4.50, despite the latest increase in the Institute minimum student wage to $4.90. The pay raise issue was debated at meetings of the Student Wage Review Committee of which Ms. McGavern is a member, and where originally a figure of $5.05 was proposed. It was UROP's conclusion that higher hourly rates would likely have a direct and negative effect upon the numbers of research opportunities available to students, and have an inflationary effect in general upon the range of Institute employment opportunities for students, ultimately carrying wage rates unjustifiably beyond other Institute, and outside, wage scales.

The largest proportion by far of undergraduate student financial support continues to come from faculty-sponsored research grants -- about $1,300,000. To supplement MIT's own ability ($250,000) to underwrite student research, we have made many efforts over the years to secure additional outside funding. One effort resulted this year in a $30,000 grant for a three-year period from New England Mutual Life Insurance Company to support students working with Whitaker College faculty. The first portion of these funds will be applied in the next fiscal year. We are the beneficiaries of a small bequest from the Raymond Stevens Fund to be used for helping undergraduate researchers learn how to speak effectively in public about their research. Raymond Stevens, Class of 1917, was formerly president of Arthur D. Little and a member of the MIT Corporation. Plans to make innovative use of these funds this coming year are under way.

The James McCormack Memorial Fund, which offers awards through UROP for undergraduate research in areas relating to technology and its applications to the problems of humanity, society, and the arts, was replenished this year by the original donors which include Draper Laboratory, MITRE Corporation, and the Communications Satellite Corporation (COMSAT). Clapp and Poliak Engineering Design Awards went to a record number of undergraduates this year: 16 individual students and a group collaborating on the building of a multi-person bicycle to break the human-powered speed record. The possibility of having this grant increased to sustain the current high level of interest by students is being explored. The Uniroyal Foundation provided a grant unchanged from previous years to help fund beginning researchers. Three were funded this year. Class of 1970 Awards were granted to two students. The Civil Engineering Department provided UROP support for 10 students chosen competitively for Civil Engineering Undergraduate Traineeships. Sea Grant Awards went to one student in the fall term and six in the spring term. A new UROP award, the Dean Horn Award, was established for students doing innovative marine research, and had its first recipient in June 1982. Another award given for the first time this year is the Joel Matthew Orloff UROP Prize. Carrying a cash award of $1,000, this prize is to be given each year to the student felt by faculty to demonstrate the most outstanding work in a physics-related area. The prize was established by the Orloff family in memory of their son, Joel, Class of 1978. Three students received materials and services support for their research from the MIT Chapter of the Society of Sigma Xi. Eloranta Summer Fellowships of $3,000 each were awarded this spring to students proposing original research to be undertaken during the coming summer months. Thought is being given by the awards committee to limiting the award to three students in the future (instead of five as in previous years) in order to allow the fellowship amount to be higher and maintain the exceptional calibre of students who apply.

UROP continues regular lively interaction with many quarters of the MIT community: faculty, administration, and graduate students, as well as with organizations off campus. Joint efforts with other MIT offices and departments are growing in emphasis. For example, together with the Undergraduate Academic Support Office (UASO) and the Career Planning and Placement Office, UROP sponsored a joint Independent Activities Period (IAP) venture called the "Summer Job Blues," an event intended to spark student interest in the many Institute resources available for planning summer activity. Together with the Department of Earth and Planetary Sciences, UROP convened a highly successful symposium for the MIT community where undergraduate student researchers in that Department presented their adventures in research. High school teachers and students from selected local schools were also invited to attend. Also departmentally, UROP students made presentations of their research at symposia in the Departments of Physics and Mathematics. Wellesley students presented their research at a campus-wide symposium co-sponsored by UROP and the Wellesley-MIT Exchange Office.

Historically, off campus UROP projects have provided to students something unavailable at MIT. With the expansion of medical research here at the Institute and the existence and growth of off

campus oriented programs (such as the Engineering Internship Program), more of what students originally were seeking from outside MIT through UROP is now available through other MIT programs and offices. This has allowed UROP to cut back on our off-campus emphasis. The years of UROP participation experience with research done in collaboration with non-MIT parties has given us a keen eye for the pitfalls and formats that make it work. Our role now is to guide students, and sometimes off-campus organizations, to appropriate programs and research formats, and provide information on liability, academic mechanisms, and legal concerns. Mr. Truesdell compiled a manual entitled *MIT Off Campus Oriented Programs*, which was made available to the MIT community this past year as a first attempt to summarize for interested parties the wide range of MIT's off-campus relationships that are available for the benefit of students.

This past year saw additional professional and personal changes among UROP staff in addition to those already mentioned. The most noteworthy personal event was the birth of a son to Susan Mitchell-Hardt last summer. Roberta Hoxie, UROP's main building tie, left to pursue new directions in her education and career. The coming fall will see the hiring of a part-time UROP clerical support person to replace our present varied part-time student clerical arrangements. Michelle Lamarre became assistant director at UROP this year. She will represent UROP on the IAP Planning Committee as a collateral responsibility. Ms. McGavern and Mr. Truesdell completed Introduction to Institute Finances, a course offered by the Personnel Office. This will be put to immediate use as Mr. Truesdell joins the IAP Finances Committee next year. Gregory Smith, UROP special projects coordinator, continues to be active in the Council for the Arts and other MIT committees. He served as a panel member in the June 1982 Black Administrators Conference. Professor MacVicar continues to serve on the Committees on Educational Policy and Discipline.

MARGARET L.A. MACVICAR

Upward Bound Program

The MIT-Wellesley Upward Bound Program is a coeducational, multiracial, multiethnic educational program for Cambridge high-school youth. Now in its 15th year, the program services 70 academically promising young men and women who have low achievement motivation 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 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 the student's level of aspiration. The program staff are often the first to see real academic promise in the youngsters. The staff, together with teachers and fellow students, play a crucial role, because what students think they can do is dependent on what others think they can do. The students' perceptions of their abilities, and therefore what they will try to accomplish, are thus to a large extent determined by the staff.

Summer Program

The summer program, conducted in residence on the Wellesley College campus for six weeks, is designed to provide the student with an intense academic and social experience. Classes are team-taught by experienced high school teachers, students from Wellesley College and 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. Each student is required to take a mathematics and an English course and one elective. Humanities

and social science offerings include 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. The mathematics program includes an enrichment section for students who are going to take algebra I or II, geometry, or trigonometry; a review section for students who have done poorly in algebra I or II, geometry, or trigonometry; and pre-calculus and calculus courses for students who will be attending college in the fall.

The Academic Year

The academic year program, while less intense, 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 to 7 pm, and two evenings per week from 7 to 9 pm. In addition, tutors are available in the offices on Saturday from 10 am to 1 pm and on Sunday from 1 to 4 pm. Tutors are on duty to provide homework supervision for both individuals and small groups. Tutors are typically MIT or Wellesley College undergraduates who meet regularly with the core staff to discuss students' progress and/or difficulties.

Tutoring. Whenever requested or needed, tutors are assigned to individual students. These pairings meet on a regular basis at a specified day and time until it is mutually agreed that the individual tutorials are no longer necessary (usually indicated by improvement in grades). Organization and time management are stressed, as well as effective negotiation techniques.

College Report, Class of 1982

Graduating seniors have been placed in colleges as follows: Franklin Institute, Simmons College, Morehouse College (2), Johnson C. Smith University, Roxbury Community College, Norfolk State University, Boston University, Ohio Wesleyan University, University of Massachusetts at Amherst, Northeastern University, Hampton Institute, Carnegie-Mellon University, Indiana Institute of Technology, and Franklin Pierce College.

We are looking forward to increased participation by MIT and Wellesley College undergraduates through our involvement in the course practicum placements of MIT seminar 212 and the Wellesley College Teacher Certification Program.

RONALD S. CRICHLOW

Wellesley-MIT Exchange Program

For the Wellesley-MIT Exchange Program, this year has been one of evaluation and growth. In September, an ad hoc committee of faculty from MIT and Wellesley issued reports evaluating the Exchange and recommending ways to strengthen it. The spring semester saw a substantial increase in the number of MIT students taking Wellesley subjects and also the establishment of a Residence Exchange.

Evaluation

In May 1980, with new administrations at both MIT and Wellesley, the Provost of MIT, Francis E. Low, and the Dean of the College at Wellesley, Maud H. Chaplin, established an ad hoc Wellesley-MIT Exchange Review Committee with three faculty members representing each school:

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 were ex-officio members of the Review Committee. Mary Z. Enterline, MIT manager of the Exchange, and Dorothy Moeller, Wellesley coordinator of the Exchange, served as staff to the Review Committee.

After an initial meeting, the two faculty groups conducted their reviews separately, and each issued a report. The MIT group sent questionnaires to MIT department heads and to all current MIT students who had cross-registered for Wellesley courses at any time in the previous six semesters.

The Review Committee concluded that the evaluation "has taught us that the MIT-Wellesley Exchange is highly valued by most of those who have elected to participate in it." The Review Committee recommended that a) MIT continue to support the Exchange, but that there be regular review by both institutions of the relative costs involved in maintaining it, and b) that the MIT-Wellesley Joint Committee be a more active and academic group with responsibility for formulating MIT's academic policy with regard to the Exchange, considering possibilities for further academic cooperation, and clarifying such matters as which Wellesley courses fulfill Institute requirements.

While the Committee found that MIT students who cross-registered at Wellesley believe education at MIT would be seriously impoverished were the Exchange discontinued, it also observed that, in general, there is widespread ignorance of the Exchange at MIT. The Committee suggested that efforts be made to increase awareness of the Exchange, particularly among students, undergraduate advisors, undergraduate officers, and department heads.

Working independently, the Wellesley faculty group came to conclusions similar to those of the MIT group. Finding that the Exchange is widely known at Wellesley and strongly endorsed by its participants, the Wellesley group recommended that the Exchange be strengthened by providing better information to students, encouraging increased faculty cooperation, and revitalizing the Joint Committee.

Cross-Registration

Even before the Review Committee report was completed,the Exchange Office at MIT had begun to increase publicity about the Exchange. New publications have been developed; Wellesley catalogues are now distributed to students, undergraduate advisors, and Department of Humanities faculty; and annual mailings are sent to undergraduate and freshman advisiors, and freshmen. Apparently as a result of these efforts, MIT enrollments in Wellesley subjects increased significantly for spring semester. In fact, for the first time in the history of the Exchange, many more MIT students than Wellesley students cross-registered. During spring semester, 257 MIT students enrolled in 297 Wellesley subjects, while 187 Wellesley students enrolled in 238 MIT subjects. The MIT cross-registration figures are the third highest they have ever been, and the highest in a decade.

Joint Courses

The MIT spring semester figures were, as usual, higher than the fall semester figures, primarily because during the spring semester Professor James Kodera of Wellesley offers Religion 108 Introduction to Asian Religions on the MIT campus. This year, 67 MIT students enrolled in the course.

Also during second semester, MIT Professor Edward Turk taught a course at the Institute that was listed in both the MIT and Wellesley catalogues (MIT 21.233 French Lyricism: From Literary Text to Opera, and Wellesley French 349 Studies in Culture and Criticism).

Two other second-semester subjects among the offerings of the Cambridge Humanities Seminar Series had dual listings: 21.366 (Wellesley History 341) The Nature and Meaning of History, taught by Professor Jonathan Knudsen at Wellesley, and 21.979 (Wellesley Philosophy 304) Theory and Practice of Metaphor, taught by Professor Linda Janik at Wellesley.

Residence Exchange

With dormitory space available at MIT due to the opening of 500 Memorial Drive, the Wellesley-MIT Joint Committee and the Offices of the Deans of Student Affairs at both schools decided to establish a Residence Exchange on a trial basis during the second semester. A previous Residence Exchange in 1971 had been successful, but MIT decided to end it when there became a shortage of dormitory space, particularly for women.

This past spring, nine MIT students and 10 Wellesley students participated in the Residence Exchange. In addition to start-up bureaucratic difficulties, there were negative reactions to the concept of coed living from a few Wellesley students. However, the Joint Committee felt that these problems resulted mainly from starting the Residence Exchange in mid-year with relatively short notice. The Joint Committee decided to continue the Residence Exchange next year and expand participation to 15 students from each school.

This year's participants in the Residence Exchange seem to have found their experiences rewarding. Of the four MIT participants who will be returning next year, two reapplied for the Residence Exchange. Five of the 10 Wellesley participants, all of whom are returning, also have reapplied.

Joint Committee and Exchange Staff

Robert J. Silbey, professor of Chemistry and a member of the Review Committee, agreed to serve as the new MIT co-chairperson of the Wellesley-MIT Joint Committee. Dean Chaplin served as the Wellesley co-chairperson. Other members of the 1981-82 Joint Committee were, from MIT, Dennis L. Doughty, Class of 1983; Ms. Enterline; Helen M. Fray, Class of 1982; Brian J. Glass, Class of 1982; Dean Holliday C. Heine; Dr. Louis Menand III; Associate Provost Perkins, Professor Joseph M. Sussman; Professor Tayler; Dr. John P. Terry; and Michael Witt, Class of 1984. From Wellesley, members were Professor Jerold S. Auerbach; Professor Theodore Ducas; Barbara Farquhar; Professor Robert D. Frye; President Nannerl O. Keohane; Dean Florence Ladd; Ms. Moeller; Helen M. Morrison, Class of 1982; and Arlene A. Rozzelle, Class of 1982.

This year members of the Joint Committee were appointed to subgroups investigating three possible areas of cooperation: the Residence Exchange, a five-year double-degree in engineering, and a Japanese Studies Program.

In the Exchange Office at MIT, Ms. Enterline continued as manager. Maryglenn Vincens, staff writer/editor, assumed additional responsibilities in developing publications for the Exchange. Angela M. Price, who had served with enthusiasm and good cheer as senior office assistant, left for California in March, and was succeeded in April by George R. Kendall.

MARY Z. ENTERLINE

Chairman of the Faculty

A major portion of the Committee on Educational Policy's work during the 1981-82 academic year continued a review of the undergraduate academic program begun by the CEP in 1980, under the leadership of Professor Sheila E. Widnall, then Chairman of the Faculty. The scope of the review, which encompasses the General Institute Requirements in Science; the Humanities, Arts, and Social Sciences Requirement; and issues relating to pace, style, and structure of an MIT undergraduate education, was described in the 1980-81 *Report of the President*. The review is being undertaken with the help of a number of subcommittees and working groups established under the guidance of the CEP. The report which follows focuses on specific accomplishments of the past year and some issues to be addressed in the coming year.

Undergraduate Writing Requirement

The Subcommittee on Writing Proficiency, established in the fall of 1980 to look into concerns in the area of undergraduate writing, submitted a final report to the CEP early in the fall of 1981. Its members were Professors Michael J. Driscoll and Kenneth R. Manning (chairman). The Subcommittee found a widespread conviction that a substantial number of MIT students do not achieve a level of writing proficiency adequate for either their course work at MIT or their professional careers later on; that the curriculum as a whole does not reflect the importance of this skill; and that the Institute and its students would benefit from proper attention to the problem.

Following extensive CEP discussions, a modified report and recommendations from the CEP were published in *Tech Talk*, and subsequently sent to the faculty in February. Formal motions were discussed at several faculty meetings in the spring, leading to strong faculty endorsement in April of a new General Institute Writing Requirement for the bachelor's degree (beginning with the Class of 1987), to be overseen by a Special Faculty Committee.

The primary objectives of the requirement are: first, to ensure minimum standards of writing proficiency for all undergraduates, with special emphasis on writing in students' professional fields; and second, to see that clear, effective writing is valued and fostered throughout the curriculum as an important part of an MIT education. The basic features of the undergraduate Writing Requirement are early evaluation, a variety of modes of completing the requirement, and Institute-wide involvement. The success of the requirement depends heavily on the acceptance of a shared, curriculum-wide responsibility to emphasize the importance of writing in all subject areas, and to provide opportunities for students to write.

The Writing Requirement is to be satisfied in two stages, broadly characterized as follows: The first stage, normally completed by the end of the first year at MIT, is concerned with the basic expository writing competence expected of any educated person. Its purpose is to provide early evaluation of each student's writing ability, and to guide students toward appropriate instruction or other support activities. The second stage of the requirement is designed to engage upperclass students over an extended period of time in the more specialized forms of writing that are necessary within their professional disciplines. These writing experiences are intended to extend beyond those provided by the Humanities, Arts, and Social Sciences Requirement. Students satisfy this part of the Writing Requirement any time after one year at MIT but generally not later than the end of their third year.

The details of the requirement will be worked out by the Committee on the Writing Requirement during the 1982-83 academic year. It is intended that the specifics be formulated with sufficient flexibility and variety so that students are encouraged to explore and to take initiatives best suited to their individual writing needs. In May, Professors Driscoll and Manning were given the Irwin Sizer Award in recognition of their substantial contribution to bringing about an awareness of the importance of writing in MIT's educational programs.

Pace and Programs

The Pace and Programs Subcommittee submitted its final report to the CEP in September 1981; an overview was subsequently published by the CEP in *Tech Talk*. Subcommittee members were Professors Merton Flemings (chairman), Wilbur Davenport, Margery Resnick, and Roy Welsch, and undergraduate members Alison Kutchins and David Lingelbach.

The Subcommittee studied and made specific recommendations on three topics related to pace in the undergraduate program and to the overall quality of the student experience at MIT. The first area dealt primarily with the freshman year. In general, the Subcommittee concluded that the freshman Pass/No Credit system has many attractive features for MIT and its undergraduates -- among them that it permits freshmen with a diversity of backgrounds to become acclimated to MIT and its pace without excessive pressure and competition, that it permits exploration of educational options which might not otherwise be attempted, and that it helps counteract the pressures and perceived impersonal atmosphere of the large core freshman subjects. However, the Subcommittee was concerned about some consequences of Pass/No Credit, in particular about the relatively high proportion of freshmen whose academic subject loads exceed what is considered to be the norm (45 to 54 units). It concluded that a high degree of overloading in the freshman year contributes greatly to the problem of pace in undergraduate life as well as to the view that an education is the mere accumulation of credit units. In addition, a number of faculty feel that the protective umbrella of Pass/No Credit grading can result in less than optimal performance by many freshmen in core subjects. The Subcommittee also found inadequacies in the system of evaluation of students' performance.

Addressing these concerns, the Subcommittee recommended a strengthening of performance evaluation and academic accountability in the freshman year, while retaining the benefits of the freshman Pass/No Credit system. Working closely with the Undergraduate Academic Support Office in the Office of the Dean for Student Affairs, and with a subgroup of the Committee on Student Affairs, the CEP has arrived at a set of proposals which are consistent with the Subcommittee's general principles. The CEP supports continuation of two terms of Pass/No Credit grading, but urges more timely and meaningful feedback to freshmen and their advisors to provide a sound basis for curricular decisions. The CEP recommends internal grades both terms for freshmen in all their subjects (except those subjects graded Pass/Fail for all students, such as UROP, Undergraduate Seminars, etc.), and suggests specific changes in the current system of narrative evaluations to encourage more useful communication between students and faculty and to streamline and improve participation in the process. These internal grades in the freshman year would be used for advising purposes only and would not restrict freedom of choice in selecting a major; the external MIT transcript would maintain Pass/No Record, as is the current notation in the freshman year, and MIT would not send copies of the internal grades to third parties.

The CEP also stresses the importance of providing students and advisors with better information about the various departmental programs than is currently available, and recommends that sample programs be prepared for each Course. These "roadmaps" would clarify curricular choices and would illustrate the interdependence of various required subjects, the consequences of various choices, and the relationship of departmental programs to the freshman year. Realistic information of this kind may help eliminate pressures for students to overload. The CEP proposals on the freshman year, currently in draft form, will be presented to the community early in the 1982-83 academic year for broad discussion prior to consideration at Faculty Meeting.

The other two areas in the report of the Pace and Programs Subcommittee dealt with departmental requirements and MIT's system for counting credit units. In the first area, the Subcommittee was concerned that departmental programs sometimes require more credit units than is generally intended under faculty rules (resulting in part from departments being able to specify subjects to satisfy the Institute Laboratory and Science Distribution Requirements), thus diminishing flexibility in the first two undergraduate years. In the second area, the Subcommittee was concerned about MIT's nearly unique system of assigning credit units to subjects, which emphasizes, misleadingly, that there is meaning, as well as great precision, in the way we currently record differences in the credit value, and effort required, in different subjects. The Subcommittee made several recommendations in these areas to help improve the quality and pace of academic life at MIT: a) to move from the detailed counting of credit units to a system of counting "subjects" (and perhaps "half-subjects"); and b) to rewrite faculty rules to specify more clearly the number of subjects that can be required, directly or indirectly, in a departmental program. The Subcommittee felt that the latter should be done in the context of assessing a fundamental question of

educational philosophy: What proportion of the total undergraduate program should be devoted to professional/departmental specialization and what proportion to educational breadth with greater freedom of choice? CEP discussion on these issues will continue in the coming year, although the likelihood of adopting the Subcommittee's specific recommendations appears low, in part because of feelings that practical difficulties of making changes in these areas may outweigh the perceived benefits.

The broader questions of pace at MIT raised by President Paul Gray in his 1980 Inaugural Address also remain before the CEP. We need to continue asking ourselves about the consequences of our frenetic pace and chronic overcommitments which limit opportunity for personal development and time for introspection. Since pace is very much a part of the culture of MIT and deeply rooted within our shared values, it is a hard issue to understand, let alone deal with.

Humanities, Arts, and Social Sciences Requirement

The Subcommittee on the Humanities, Arts, and Social Sciences (HASS) Requirement, chaired by Professor Anthony French, undertook a survey this past year of those departments offering subjects which satisfy the HASS Requirement. Some of the issues explored were: a) the appropriateness of the current division in the HASS Requirement among distribution, concentration, and elective components; b) the achievement of a reasonable balance among the humanities, the arts, and the social sciences in students' specific programs; c) the amount of credit units HASS subjects offer (most often nine units); d) the appropriateness of the current criteria for designating HASS Distribution subjects, and of the relatively large number of such subjects now available; and e) the way in which the requirement is currently administered, including the role of the Committee on the HASS Requirement. A basic question concerns the fundamental objectives of the HASS Requirement within the MIT educational experience. Another concern is the difficulty of communicating options in the HASS curricula to students and advisors in ways that would help to provide a better basis for making educational choices. The Subcommittee has been compiling a great deal of information which will be given, along with the survey results, to next year's CEP for continued deliberation.

Institute Science Requirements

The working groups of the Subcommittee on the Institute Science Requirements each submitted an interim report at the end of the 1980-81 academic year. The working groups were chaired by Professors Richard Cartwright, Vernon Ingram, Robert Fano, and Glenn Berchtold. These reports in essence recommended: a) that a subject in biology be added to the current core science requirements, following the rationale that some fundamental understanding of life processes should be a basic part of an MIT education; b) that the Science Distribution Requirement in its present form be abolished, because it does not play a sufficiently significant educational role (and has never served the purposes of educational breadth and fundamental scientific inquiry envisioned at the inception of the requirement in the mid-sixties); and c) that the Laboratory Requirement be retained, with emphasis on project-type work, though restricted in subject matter to the natural sciences. Laboratory experience in the latter was viewed by the working group as an essential component of any broad, liberal curriculum designed to provide a general education in the natural sciences. The response to these proposals has been very mixed; indeed, they raise several basic questions that will need to be addressed by the CEP before arriving at any recommendations, among them: What is the fundamental purpose of the Institute Science Requirements, and what is their impact on non-science/non-engineering majors and on the diversity in our undergraduate students? What would be the impact of further additions to the core science requirements on the pace at MIT, on student flexibility to explore areas not bound by requirements, and on departmental programs? Because of time constraints this past year, little follow-up was made on these issues, and they remain central CEP agenda items for the fall.

As the undergraduate program review continues, it is important that all the issues addressed be considered within the context of maintaining a stimulating and challenging environment at MIT for students and faculty. It is essential that we reassess periodically our vision of what MIT's educational mission should be.

Other Issues

In addition to the undergraduate program review, the CEP addressed several other questions during the past year:

1) Each term, undergraduate and graduate students from a variety of departments report violations of Faculty Regulation 2.51 governing the end-of-term scheduling of examinations, quizzes, term papers, take-home exams, and other assignments. Such violations, while generally well-intended, can work hardships on students, given their overall load of four or five subjects. The CEP prepared a policy interpretation of the end-of-term regulations, which was sent in a letter to all faculty members in November. Greater awareness of the rules by both faculty and students is expected to substantially address the matter. The letter also raised concerns about whether the teaching staff in general is making the best use of the Reading Period and Final Exam Week for the educational benefit of our students, and whether the practice of giving relatively few exams during Finals Week is in fact making the end-of-term pace more hectic than it need be. Some students have four or five quizzes during the last two days of classes, in effect shortening the term for these students by one week and adding to the hectic pace. The CEP is encouraging instructors to take advantage of the educational benefits of the Reading Period by giving an exam (even if only an hour long) during Finals Week, rather than giving a quiz during the last week of classes.

2) The CEP reviewed, at the request of the Committee on Academic Performance, a policy being considered by the Department of Electrical Engineering and Computer Science under which their majors would "not normally be permitted to register for a subject in the departmental program if they receive a D or F in a prerequisite subject; normally, such a student should retake the subject." The policy was in response to departmental concern about the professional qualifications of a small number of their majors at graduation, characterized by a string of D's. The policy would provide early warning and allow something to be done to help these students before they get too far into the program. The CEP, while neither recommending nor discouraging such a policy for individual departments, did find that the policy was consistent both with the current definition of the D grade and with the underlying guiding principle that a department, through its advisors, can exercise the prerogative of not allowing its students to take subjects for which they are not prepared. The CEP developed a general framework under which such a policy would be acceptable, and felt that the central focus of the D grade policy should be the student/advisor relationship. The CEP statement of the policy is that: "Some departments may consider D level work in certain prerequisite subjects within the departmental program to be inadequate preparation, and may ask students to do additional work, which could include retaking the prerequisite." The CEP expects prerequisites to be understood in terms of substantive intellectual content and foundation for further work in the student's program. It is expected that any department which considers adopting such a policy will remain flexible in its views on how deficiencies might be remedied, and that departments will explore alternative forms of additional work rather than just routinely require prerequisite subjects to be retaken. While the D grade policy can be applied only to prerequisite subjects listed in the departmental program, it can be applied regardless of when students take the subjects, even if during the freshman year (to the extent this grade information is available to the sophomore advisor). The D grade policy may not include those subjects taken in the freshman year used to satisfy the core science requirements and the HASS Requirement. Several departments have indicated that they might adopt procedures with respect to D grades along the general lines described above.

3) In the past few years, the CEP has reviewed requests from several MIT programs to include special descriptions and subject listings in the MIT catalogue. Apart from addressing the specific merits of each of these requests, the need has emerged to provide greater clarity both in the ground rules for presenting subject descriptions in the catalogue (questions of length, multiple descriptions, handling subjects not given each year, and so forth), and in the ground rules and objectives for presenting the departmental and interdepartmental programs. An ad hoc group consisting of representatives from the CEP, the Committee on Curricula, and the Committee on Graduate School Policy, as well as from various administrative offices, is being set up to begin a broader reexamination of the catalogue to make it more readable, manageable, and useful to the various audiences it serves.

4) The CEP responded to a number of *ad hoc* matters that arose during the year, such as reviewing changes in the degree programs of several departments and recommending changes in Faculty Regulation 2.11 to specify the date of Commencement in years when the normal statutory date coincides with Memorial Day.

Future Agenda

In the coming year, the CEP will continue work in areas previously described, along with some routine reviews that are scheduled. In addition, the agenda will include: a) a further look, together with the Committee on Student Affairs, at the system of advising in the freshman year and related issues (for example, getting more regular faculty involved and appropriately recognizing this service, communicating routine information to freshmen more effectively, and providing for more natural advising settings, such as through Undergraduate Seminars and UROP); b) exploration, with the academic departments and the Committee on Undergraduate Admissions and Financial Aid, of various admissions- and enrollment-related issues; and c) continued discussion of issues raised by the 1981 *Report of the IAP Policy Committee*, including development of an appropriate statement of what the Independent Activities Period should be and what constitutes reasonable fulfillment of educational responsibilities during IAP.

The following retired from the CEP at the end of the 1981-82 academic year: Professors Lotte Bailyn, Glenn Berchtold, Wilbur Davenport, Joseph Ferreira, Anthony French, Vernon Ingram, and Cynthia Wolff, and student members Robert Duncan, Therese Prisby, and Lesley Saunders. Their contributions and service are much appreciated.

FELIX M. H. VILLARS
DAVID S. WILEY

School of Architecture and Planning

The enduring strength of the School of Architecture and Planning is particularly evident at this time in our history. We are continuing in our teaching and research to emphasize the social context for the practice of architecture and planning and the ways in which that practice can be even more responsive to the needs of a plural society. At the same time, the School has had the energy and imagination to engage in the debates and changes that will have far-reaching consequences in our professions and in the universities.

Changing expectations about the public and private responsibilities for environmental quality continue to emerge in architecture and planning. Economic conditions call for new approaches to practice; the diminishing Federal participation in urban and regional issues creates uncertainty and new pressures on state and local governments. In a day-to-day sense, these changes have their effects in the conduct of the School's activities. Although these effects may take a number of years to become dramatically apparent, certain signs are already clear. The School is less able to provide financial support for graduate students at the level of recent years, students generally perceive fewer career opportunities in applied social sciences, and there is a corresponding fall in undergraduate enrollment in the urban studies and planning major. (Enrollment figures for the School as a whole continue to be strong. For details see the charts accompanying this report.)

In many ways the School this past year was compelled to be very sensitive to the economic conditions within which it is conducting its activities. From the Institute's point of view, the need to reduce costs in the academic budget will lead to a reduction in real terms of three percent in the School's budget for 1982-83, and the probability of similar reductions over following years. Achieving these reductions has called for thoughtful attention by the departments and the Laboratory of Architecture and Planning to ways to cut costs while new areas of activity are being developed.

The overwhelming importance of the shortage in financial aid for graduate students has led to the decision to develop a plan for raising significant new funds for student aid in the School. This development plan will be a major part of the School's agenda for 1982-83. Exceptional efforts were also made during the year to sustain current sources of financial support, e.g., the Housing and Urban Development (HUD) Minority Intern Program. Sustaining existing sources of support is a vital priority, while implementation of the School's development takes place.

The School's central interest in practice urges a fresh look at the content and curriculum of the School's professional programs. In the case of the Department of Urban Studies and Planning (DUSP), this has involved a review of the undergraduate degree program and agreement by the Institute faculty and the Committee on Educational Policy (CEP) to change the title of the undergraduate program from Bachelor of Science in Urban Planning to Bachelor of Science in Planning, and to emphasize applied social research in the undergraduate course requirements. In the Master in City Planning (M.C.P.) program, a Department committee developed a new core program to consolidate and strengthen the first semester's M.C.P. studies. This will be implemented in the fall of 1982.

As Interim Head of the Department of Architecture, Professor Julian Beinart undertook to prepare an agenda for the Department to guide it through the changes and developments in its activities over the years to come. In preparing this agenda, Professor Beinart reached out to the alumni and professional community in the Boston area for input and also obtained systematic and thoughtful response from faculty, students, and staff within the Department. The outcome of the agenda-building effort will include recommendations on Department communications, resources, and curriculum as well as day-to-day operational aspects including mentor relationships, social activities, and training of teaching assistants.

The Visiting Committee

During the year the Visiting Committee for the School met as three subcommittees for Urban Studies and Planning, Architecture, and Arts and Media Technology. The first two of these visiting subcommittees met at the School in the spring and reviewed in detail the content and direction of the work in their departments. The Arts and Media Technology subcommittee will visit the School in the fall of 1982. A meeting of the full Visiting Committee will take place in December to consolidate the Committee's report to the Corporation.

The subcommittee review of the two departments was very successful in terms of the range and intensity of discussion. Both meetings received presentations on research, picking up on the research theme that was central to the previous full Visiting Committee meeting in the fall of 1980. Both departments indicated a continuing strength in applicant pools, but expressed concern about the challenge of maintaining the diversity of the student body in the face of current economic conditions and rising tuitions.

DUSP made a major presentation on the new core curriculum of the M.C.P. Program, which was received with interest and support by the subcommittee.

Presentations by the Department of Architecture included a preliminary review of findings that emerged from the agenda-building task under way in the Department. A full review of studio work was also undertaken, and the Committee indicated a more confident feeling about the quality of the work they saw. At the same time they sensed that the Department could do a better job of communicating its diversity and richness both within and outside the Department. Recurrent themes throughout both subcommittee meetings were the problems of space and financial aid.

Arts and Media Technology

In December of 1981, President Paul Gray announced the Institute's intention to proceed with the building of the new Arts and Media Technology (AMT) facility. This decision heralds, in a tangible way, a major development in the history of the School of Architecture and Planning. As now planned, the AMT facility will be host to a significant sector of faculty in the Department of Architecture, and in particular to those whose education and research efforts are related to the Master of Science in Visual Studies (S.M.Vis.S.) program.

Underlying the decision to proceed with the Arts and Media Technology facility is the confidence shown by donors that the building can be host to creative and research activities of remarkable interest and importance to the world of art, publishing media, and human-machine systems. In response to this decision, the Dean of the School undertook to chair a task force, including Professors Beinart, Nicholas Negroponte, and Dr. Jerome B. Wiesner, which would make recommendations on the design of the structure, and on the governance of the activities to be housed in the new facility. The task force would also provide an update on the goals to be achieved across the program for arts and media technology. To assist the task force, an all-day seminar was held in May to discuss the goals and directions of arts and media technology both within the Institute and elsewhere in the country. Occupancy of the new building is expected in the fall of 1984.

Space

For many years space problems have plagued the Institute and, more specifically, our School. In December 1981, a long-term strategy for the amount and location of School space was prepared. The strategy suggested consolidation of School-wide activities in the space currently occupied at the center of the campus and growth of specialized functions within the School at two locations peripheral to the center, which are north of the campus and on the west campus in the new Arts and Media Technology building. This strategy also identified as the highest priority the expansion and improvement of Rotch Library space and recognized that this task will require exceptional funding support.

Major School renovations were completed in the fourth floor architecture studios in Building 5. These renovations, designed by faculty member Barry Zevin, are part of a longer-term plan for the improvement of studio exhibition and review space in the School; the result is a very successful new arrangement of the space, with very high-standard construction by our students.

Other recent important space initiatives continue to be implemented as planned. With the development of the S.M.Arch.S. degree program to its full complement of students, part of the space required for the program was successfully transferred to Building N52, five blocks north of Building 7 on Massachusetts Avenue. The ground floor of the neighboring N51 Building has also been adapted for use by the Visible Language Workshop and the Film Video components of the S.M.Vis.S. degree program.

New opportunities were sought during the year for faculty and students to make a positive input to the continuing task of planning and building within MIT itself. These included participation by the Dean in the deliberations of the Administrative Housing Group and a presentation to that group by School faculty and graduates of innovative nonprofit housing design and financing techniques.

Educational Leadership

Members of the School continue to play a leading role in national collegiate associations of schools of planning and architecture. The chairman of the Department of Urban Studies and Planning, Professor Lawrence Susskind, has been instrumental in the coordination of a national debate on the accreditation of planning schools within the Association of Collegiate Schools of Planning and the American Planners Association.

Together with the Boston Architectural Center (BAC), the School has been making plans for the 1982 Northeast Regional Conference of the Association of Collegiate Schools of Architecture, which will be held at MIT and the BAC in the fall of 1982 and will include access to concurrent sessions of the American Institute of Architects Design Committee being held at the Harvard Graduate School of Design.

The School's Laboratory of Architecture and Planning (LAP) is one of the most active university research centers of its kind. Michael Joroff, Director of the LAP, has played a leading role in the establishment of the Architectural Research Centers Consortium, Inc., and is currently acting as chairman of that organization.

Administration

In the Fall of 1982 Professor Gary Hack will take over for Professor Susskind as Head of the Department of Urban Studies and Planning. Professor Hack has been a central figure in the development of the School's Environmental Design Program. His appointment continues the recent tradition in the Department to select a tenured associate professor to take on the challenge of Department chairmanship for a four-year period.

Also in the fall of 1982 Professor John Myer will take up the duties as Head of the Department of Architecture. His selection for this position was the outcome of a national search. Professor Myer brings with him a deep understanding of the Department and MIT, along with a distinguished record as a practicing architect.

This year was also the first in the administration of John de Monchaux as Dean of the School of Architecture and Planning. In this task he has received the strong support of not only the School and its alumni, but of the MIT community as a whole.

JOHN de MONCHAUX

STUDENT ENROLLMENT AND COMPOSITION 1981-82

	Total	Women	%Women	Minority	%Minority	Foreign	%Foreign
Department of Architecture							
Undergraduate	85	28	33%	5	6%	10	12%
M.Arch.	119	47	39%	11	9%	10	8%
S.M.Arch.S.	62	14	23%	4	6%	45	70%
S.M.Vis.S.	39	13	33%	4	10%	1	3%
Ph.D.(resident)	13	6	46%	0	0	7	54%
Special Students*	8	2	25%	0	0	1	13%
Joint M.Arch./M.C.P.	5	1	20%	0	0	1	20%
Architecture Totals	331	111	34%	24	7%	75	23%
Department of Urban Studies and Planning							
Undergraduate	13	7	54%	0	0	1	8%
M.C.P.	84	45	54%	8	10%	26	31%
Ph.D.(resident)	48	19	40%	25	52%	6	12%
Joint M.C.P./M.Arch.	8	3	38%	2	25%	2	25%
Special Students*							
SPURS**	14	3	21%	14	100%	0	0
CFP**	7	3	43%	0	0	7	100%
Other	3	2	67%	0	0	0	0
DUSP Totals	177	82	46%	49	28%	42	24%
School							
Undergraduates	98	35	36%	5	5%	11	11%
Graduates	378	148	39%	54	14%	98	26%
Special Students*	32	10	31%	14	44%	8	25%
TOTAL ENROLLMENT	508	193	38%	73	14%	117	23%

* 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.

FACULTY, OTHER ACADEMIC STAFF, AND RESEARCH STAFF -- 1979-80, 1980-81, 1981-82

	Total	E.F.T.	Women	Minority	Total	E.F.T.	Women	Minority	Total	E.F.T	Women	Minority
	1979-80				1980-81				1981-82			
Architecture												
Faculty	35	31.5	6	2	35	31.3	6	2	34	28.5	4	1
Other Academic Staff	33	17.5	10	-	54	19.5	15	2	59	25.0	14	1
Research Staff	7	6	-	-	9	6.5	1	-	7	6.5	-	-
Without Pay	-	-	-	-	11	7	4	-	14	10.0	3	0
DUSP												
Faculty	27	24.6	3	5	32	26.33	4	5	28	23.50	4	4
Other Academic Staff	19	10.38	7	2	9	5	1	3	16	6.25	1	3
Research Staff	3	1.7	2	-	1	0.25	1	-	3	2.20	-	-
Without Pay	9	-	3	1	2	-	-	-	6	-	-	1
Laboratory of Architecture and Planning												
Faculty	-	-	-	-	-	-	-	-	-	-	-	-
Other Academic Staff	2	2	-	-	2	2	-	-	2	2	-	-
Research Staff	4	4.51	3	-	11	5.3	7	-	8	4	5	-
Without Pay	9	-	3	-	9	4.15	3	-	11	8	5	-
SCHOOL TOTALS												
Faculty	62	56.1	9	7	67	57.63	10	7	62	52	8	5
Other Academic Staff	54	29.88	17	2	65	29.8	16	5	77	33.25	15	4
Research Staff	14	12.21	5	-	21	12.05	9	-	18	12.70	5	-
Without Pay	18	-	6	1	22	11.15	7	-	31	18	8	1

Department of Architecture

With the stepping down of Professor John Habraken as Head of the Department in 1981, the Department decided to use the 1981-82 academic year to review many of its activities prior to the appointment of a new Head. This process of "agenda-building" was led by Professor Julian Beinart as Interim Head and involved various student, faculty, and alumni groups, as well as the Corporation Visiting Committee.

Among the issues examined was the way the Department maintained communication among its diverse parts and how it related to outside groups. Experiments were undertaken with an internal newsletter and a lecture series oriented to the Department, as well as to alumni and professionals in the Boston area.

The lecture series, titled "City Building," featured lectures by seven faculty members who taught in the Department during the spring semester. Among these were Adjunct Professor Giancarlo De Carlo; Visiting Professors Paolo Ceccarelli from the University of Venice; Françoise Choay from l'Institut d'Urbanisme, University of Paris; Balkrishna Doshi from Ahmedabad, India; Jerzy Soltan, Professor Emeritus from Harvard University; and Henry Millon, Dean of the Center for Advanced Study in the Visual Arts, National Gallery of Art.

In addition, a lecture series directed towards amplifying the discussion of "agenda-building" issues was organized in the fall semester. Speakers were Professors Robert Gutman from Princeton University, Donlyn Lyndon from the University of California at Berkeley, and Peter McCleary from the University of Pennsylvania. Dean Emeritus Lawrence Anderson reviewed the history of the Department since its inception in the late nineteenth century.

Meetings with Boston-area alumni suggested a number of ways in which the Department and alumni could improve their relationship. Following these meetings and discussions within the School of Architecture and Planning Council, the Council has proposed that the Departments of Architecture and Urban Studies and Planning publish regular internal newsletters in addition to issuing a less frequent publication oriented to alumni and others outside the School.

The "agenda-building" program also focused on the Department's resources and the prospects of change in its budget, its capacity to provide student financial aid, its research volume, and its space requirements. With the need to reduce its authorized budget by 10 percent over the next three years, the urgency for the Department to develop non-Institute sources of funding has become greater. The Dean has therefore undertaken an effort to coordinate development activities within the School. With the cooperation of the Resource Development Office, work proceeds on raising endowment for a chair in building technology. Such efforts must be enlarged for the Department to maintain the quality of its academic programs over the coming years.

The highest priority remains the Department's need to supply financial support to students applying to its degree programs. Despite the fact that the Department this year provided students with the largest amount of financial aid in its history -- approximately $267,000 -- tuition and other increases in the cost of studying at MIT pressure the Department to increase its scholarship resources. Close to half of the total amount given to students comes from interest on endowment funds dedicated to the Department. Enlarging these funds would allow the Department to help students from a variety of economic backgrounds and ensure their coming to study architecture at MIT.

The Department had a total of 323 students enrolled as regular students in its degree programs in 1981-82 as follows: Ph.D. (13), S.M.Arch.S. (65), S.M.Vis.S. (39), M.Arch. (121), and B.S.A.D. (85). Of this total 34 percent were women, 7 percent were minorities, and 23 percent were international. The number of applications received for admission to all programs for the fall of 1982 -- 544, was only slightly lower than that of the previous year -- 562.

In the largest degree program, the M.Arch., the number of applications exceeded acceptances by a ratio of seven to one.

The research component of the Department shows steady growth both in funded research and in the "Research for Credit" program instituted this year under the direction of Professor Habraken.

The "agenda-building" process focused on two major aspects of the curriculum in the Department: the future of the teaching in the Arts and Media Technology area and the nature of our education in the professional program in architecture, the M.Arch. program.

In December 1981, the Institute decided to proceed with construction of a new building for teaching, research, and performance in Arts and Media Technology at MIT. This decision led to the formation of a task force to study the future occupancy of the building and to make proposals for the organization of the various activities involved with arts and media technology. Among the issues which affect the Department are the constitution of the various areas in the S.M.Vis.S program, their governance and budget, and the role of history, theory, and criticism in the program. Professor Beinart, Dean John de Monchaux, Professor Negroponte (chairman of the S.M.Vis.S. degree program), and Institute Professor Jerome Wiesner comprise the task force which will report on its work in the fall of 1982.

A number of tasks were undertaken in relation to the M.Arch. curriculum. The most important of these was an interview study of the students and faculty to determine opinion about certain key dimensions of the M.Arch. program. Among these were issues dealing with admissions, advising, and the administration of the program; the content of subjects and their adequacy as professional preparation; the teaching of representation, technologies, and history in relation to the teaching of architectural design; and the nature of the subject sequence including the introductory sequence and the thesis requirement. A report of the responses was reviewed at an all-day meeting at Endicott House, and a new administrative mechanism for implementing some of the proposals was recommended.

A full report on all the agenda-building activities will be reviewed by the Department in the fall of 1982.

PROFESSIONAL PROGRAM

The professional architecture program was guided this year by an advisory group, working with Professor Beinart, which reviewed faculty positions for design teaching, organization of the admissions process, future roles for visiting design teachers, and the teaching of technical subjects to support design studio. The group included Professors Leon B. Groisser, Imre Halasz, Shun Kanda, Richard Tremaglio, Jan Wampler, and M.Arch. students Ann Compton and Onaje Jackson.

The Department continued its practice of inviting distinguished practitioners to participate in advanced-level studio teaching. Architect Herb Greene, Professor at the University of Kentucky, visited in the fall term; Mr. Doshi, Director of the Vastu-Shilpa Foundation for Studies and Research in Environmental Design, Ahmedabad, India, and Mr. De Carlo, Director of the International Laboratory for Architecture and Urban Design (ILAUD), Milan, Italy, spent three weeks in the spring term working with the Level III students of Professors John Myer and Fernando Domeyko.

Though space remains a critical problem, the Department was happy to celebrate the opening of renovated architectural design studio space on the fourth floor of Building 5. The design by Professors Maurice Smith and Barry Zevin is part of a larger renovation scheme proposed for the entire studio space in Buildings 5 and 7. Work on the Building 5 portion was supervised by Professor Zevin and built mostly by Department student labor, achieving very high quality. All the Level II and III studios were located in the renovated space and greatly benefited from the improved community facility.

Master of Architecture Program

A brochure of architectural studio design work was published in the fall term. Included were representative student projects selected from each spring 1981 studio and from 4.01 Issues in Architecture and 4.26 Built Form Observation. The publication, distributed to all students and alumni, was made possible by a donation from the estate of Walter D. Burger, Class of 1927.

This year MIT joined a consortium of schools participating collectively in the International Laboratory for Architecture and Urban Design (ILAUD). Five students studied this fall in Urbino, Italy. Professors Lyndon (University of California at Berkeley), Charles Moore (University of California at Los Angeles), and Melvin Charney (University of Montreal, Canada) were faculty representatives for the consortium. Plans are now being formulated for the 1982 ILAUD session to be held in Siena.

A new format for end-of-term reviews was implemented at the close of this academic year. Three days of reviews of individual student work in each studio were followed by two days of general discussion. The sessions, open to the entire Department, dealt with studio projects in each of the three levels, exploring and defining their common issues and objectives. Professor Antonio Santos, Head of the Department of Architecture at the University of Toronto, and Professor Soltan, of the Harvard Graduate School of Design, joined the design faculty and students for the review week.

Professors Robert Slattery and Wampler were the principal readers for the Admissions Committee for applicants from outside of MIT; Professors Kanda and Groisser and and six M.Arch. students joined them for the final decisions.

The student-run M.Arch. lecture series featured a full schedule of excellent speakers including Christo, the noted environmental artist, and Arthur Erickson, distinguished Canadian architect.

Awards to graduating M.Arch. students in 1981-82 were as follows: an American Institute of Architects (AIA) Award was given to James Anderson, and Thomas Hille received the AIA Certificate. Thomas Chastain was awarded the Alpha Rho Chi Medal for Promise of Professional Merit. Roger Shepley received the Chamberlain Prize for Achievement in Design. William Gilchrist, Alan Joslin, Andres Mignucci, and Patricia Seitz were awarded Chandler Prizes for Design.

Ph.D. Program

Since the Ph.D. program began, the vast majority of Ph.D. candidates has been engaged in the area of History, Theory, and Criticism of Art and Architecture. This year, slow expansion into other areas began with the award of one doctoral degree in Media Technology and the acceptance of a total of four more candidates in the Media Technology and Housing Design areas. Interest in the program continued to be high, and the quality of candidates is perceived to be increasing in excellence. However, financial support for these excellent candidates continues to be a crucial problem. Professor Stanford Anderson chaired the Ph.D. committee this year.

Two prolonged searches for faculty to teach in the Ph.D. program were completed this year, resulting in the appointment of Kurt Forster, Professor of Art and Architecture, and Yasser al-Tabba, Aga Kahn Assistant Professor of History, Theory, and Criticism of Islamic Architecture and Urbanism. Professors Forster and al-Tabba will join the faculty in the academic year 1982-83.

Events in the Ph.D. program this year included a large conference organized and sponsored by the History, Theory, and Criticism (HTC) faculty in conjunction with the American Academy of Arts and Sciences. The interdisciplinary study conference, titled "Conventions, Canons, and Criticism," was open only to students and faculty directly involved in HTC study and research programs. MIT participants were Professors Anderson, Habraken, and Choay.

HTC Symposium 3, "Le Corbusier," was one of an ongoing series of smaller conferences organized by the program. The symposium was scheduled in conjunction with the publication of the *Sketchbooks of Le Corbusier* by the Architectural History Foundation and MIT Press in November 1981.

The Ph.D. Forum offered 14 meetings with scholars and professionals from the region who informally presented some aspect of their work; discussions followed with Ph.D. students and faculty.

A generous gift to the doctoral program by Wayne Vesti Andersen enabled virtually all of the HTC faculty and graduate students to travel to Istanbul and its environs in August 1981. Professor David Friedman planned this successful trip.

Ph.D. student Joseph Siry represented MIT at the annual meeting of the Society of Architectural Historians, presenting a paper on Louis Sullivan's Carson Pirie Scott Store in Chicago. Other Ph.D. students who received awards were Hilary Ballon, Chester Dale Fellow, National Gallery of Art, Washington, D.C.; and Hazem Sayed, Aga Khan Fellow.

S.M. Architecture Studies Program

The Master of Science in Architecture Studies (S.M.Arch.S.) program, now in its third year, continued to grow and flourish. The degree committee, chaired by Professor Habraken, worked to further develop communication between the three sections of the program -- Building Technology, Housing and Settlement Design, and Environmental Design -- and to build greater research opportunities for students.

In the fall term, a series of seminars was organized in which seven members of Department faculty made presentations of their work and offered follow-up sessions for discussion with students. Professors Habraken, Horacio Caminos, Gary Hack, Eric Dluhosch, and Tunney Lee from the S.M.Arch.S. program; Professor Smith from the M.Arch program; and Professor Anderson from the Ph.D. program each led seminars, which were attended by students from the whole Department.

A second edition of the Department publication *Abstract* appeared in the spring term. The collection of articles by S.M.Arch.S. students discussed the Forum seminars, thesis work under way, and other student concerns related to the program.

A three-year research incentive program which began this year was made possible by support from the Ernest A. Grunsfeld Memorial Fund and matching funds from MIT. Research projects proposed by faculty were awarded funding for student research assistants. The intention of the Grunsfeld awards is to assist the development of promising research ideas which may subsequently become eligible for outside funding. Michael Joroff, director of the Laboratory for Architecture and Planning (LAP), and Professor Habraken were responsible for selection of projects and administration of the program. Six projects were selected for grants in the spring term.

At the initiative of the S.M.Arch.S. degree committee, additional opportunity was afforded for student participation in research by the "Research For Credit" subject (4.781) offered in the spring term. Thirteen research topics were offered under this subject number by 11 faculty in the program; 29 students from all Department programs were involved in work for academic credit. Topics ranged from "Application and Evaluation of Given Support and Tissue Systems" to "Design with Computers."

Using methods largely developed by Stichting Architecten Research (SAR), Professor Habraken, Professor Nabeel Hamdi, and students in the Housing Group worked to generate design ideas for the renewal of the existing public housing development at Orient Heights, East Boston. The project, supported by the Boston Housing Authority (BHA), was undertaken at MIT in collaboration with the BHA and tenants of the project at Orient Heights.

A search for an Assistant Professor of Economics in Architecture was concluded during the year, with an appointment to become effective in 1982-83. It is expected that the new faculty member will teach the program's core economics subject and participate in research.

S.M.Visual Studies Program

The Master of Science in Visual Studies program comprising Film/Video, the Creative Photography Laboratory, the Visible Language Workshop (VLW), Architecture Machine Group, and the Center for Advanced Visual Studies (CAVS) was chaired by Professor Negroponte. The group continued to build artistic and intellectual connections in teaching and research, in anticipation of the final realization of the long-planned Arts and Media Technology program.

Distinguished visitors to the program included Dr. Estelle Jussim, Professor of Film and Visual Communication at Simmons College, who taught a graduate seminar on "The Context of Photography" at the Creative Photography Laboratory; Pierre Beauviala, designer of the Aaton camera, who discussed design concepts of the camera and their implications for moviemaking, in an intensive two-day workshop; and Jean Rouch, leading ethnographic filmmaker, who returned to the Film/Video section this year to conduct a highly successful week-long workshop.

The Film/Video Group's Monday Night Screening series continued this year, supported by a grant from the Louis B. Mayer Foundation. Public presentations by a diverse group of visiting moviemakers at the Monday screenings were followed by discussions with the artists in the Visiting Artists Workshops on Tuesday mornings.

The Creative Photography Laboratory continued to offer a full exhibition schedule and lecture series in its gallery. In addition, the third edition of the graduate student publication *Positive* was prepared with support from the Polaroid Corporation.

In November, the Visible Language Workshop sponsored a two-day conference, "New Technologies: New Language? New Vision?" Participants from the fields of science, visual communication, and education discussed theory, applications, and social and political implications of new communication technologies.

During the Sky Art Conference held at MIT this fall, the VLW collaborated with the Center for Advanced Visual Studies in "Data Network," which involved transmitting video images via slow-scan over phone lines between the two labs.

In June 1982, the VLW, along with the MIT Press and Design Services, received the Design Leadership Award from the American Institute of Graphic Arts (AIGA). This award, given by the oldest and largest graphic design organization in the United States, is one of the nation's most prestigious design awards. Work in various media by designers and artists at the VLW will be published in the AIGA Annual in October 1982.

The documentary film *Community of Praise* by Professor Ricky Leacock, Director of the Film/Video section, was part of a Public Broadcasting series titled "Middletown, USA." *Community of Praise* was aired nationally in April and was subsequently selected for screening at the Lille Festival, France, and the Margaret Mead Festival, New York. *Rebuilding an Old Japanese House* by Professor Leacock and Rachel Strickland won the gold medal for documentaries in the 25th competition of Films on Japan.

Professor Negroponte, chairman of the S.M.Vis.S. program, has been named by the government of France as first director of the newly created World Center for Microcomputer Science and Human Resources. The Center will concentrate on design and development of personal computer systems for education and training in industrial countries and the Third World. Professor Negroponte will take partial leave from MIT for two years.

Professor Starr Ockenga, Director of the Creative Photography Laboratory since 1976, has submitted her resignation effective in June 1983. Professor Michael Bishop will assume responsibility for the Laboratory's management in the coming year.

RESEARCH

Funded research in the Department of Architecture passed the $2 million mark, growing from $1,880,000 in the last fiscal year. Funding in the Architecture Machine Group represented more than half the Department total; the balance of Department research, administered through the Laboratory for Architecture and Planning, totaled nearly $800,000.

Research at the Architecture Machine Group has shifted into the more general domain of Media Technology and computationally augmented communication. Funded projects included: "Thinking in Color," a personalized news informational system; "Movie Manuals," which develops the notion of an electronic book; and "Transmission of Presence," which emphasizes local intelligence as a means of enriching telephone conversations. New work included the development of the next generation of computational television receivers under a contract from the Atari Corporation.

Professor Ronald MacNeil of the Visible Language Workshop completed the design and fabrication of a computer-controlled, large-scale, x,y airbrush plotter, which paints full color, high-resolution images up to 20 by 50 feet in size. The projects was supported by a grant from Compupaint, Inc.

The Department of Energy continued to fund the development of an addition to Solar House V. Named the "Crystal Pavilion," the addition utilizes heat mirror glass for passive solar energy. The Crystal Pavilion was designed by M.Arch. student Brian Hubbell and opened to the public in spring 1982. The project was supervised by Principal Research Associate Timothy Johnson. Supported by Consolidated Edison, New York, Mr. Johnson also supervised research on the development of ceiling panels for cooling, which utilize air conditioning at off-peak energy hours.

Professor Harvey Bryan was principal investigator of a project supported by the National Endowment for the Arts, "Energy-Conscious Design Education," using visual documentation techniques and physical scale modeling in energy-conscious design teaching. Professor Bryan also held a grant from the Lawrence Berkeley Laboratory for research on Interior Daylight Illumination.

With funding provided by the Administration on Aging of the Department of Health and Human Services, Professor Sandra Howell continued as principal investigator of "Determinants of Housing Choice Among the Elderly." The project coordinates the work of researchers at seven universities on issues affecting decisions of aging people to move or stay in their residences.

Professor Beinart was principal investigator, with Professor Edward Robbins, of a project funded by the National Endowment for the Arts to study the impact of telecommunications technology on built form and settlement patterns.

In addition, opportunities for student research were greatly expanded by the institution of two programs -- Grunsfeld Research Incentive Grants and Research For Credit -- described under the S.M.Arch.S. program earlier.

FACULTY

Of central interest to the Department was the search conducted throughout the year for a permanent Head to replace Professor Habraken. A search committee, named to advise the Dean, was composed of Professors Anderson, Hack, Howell, Negroponte, Slattery, graduate students Mina Marefat and James Anderson, and chaired by Professor Smith. Their recommendation, submitted to Dean de Monchaux in April, was for the appointment of MIT Professor John Myer, a member of the Department faculty since 1959. Professor Myer will assume the role of Head effective September 1, 1982.

New faculty appointments this year were Associate Professor Domeyko, who will teach architectural design, Professor Hamdi, who was appointed to the Housing Group, and Professor Kenneth Sloan, who will teach subjects on computers and graphics.

Visitors invited to teach on term architectural design studios in the M.Arch. program during the fall term were Gerhard Kallmann, Professor Emeritus from the Harvard Graduate School of Design, who taught a Level III studio, and Bengt Edman, Professor of Architecture from Lund, Sweden, who taught a Level II studio. In the spring term, William Warner, architect and former Professor of Architecture at the Rhode Island School of Design, and Gabriella Goldschmidt, Technion-Israel Institute of Technology, Haifa, taught in Level II; Douglas Engel, architect from Carouge, Switzerland, taught in Level I.

In the History, Theory, and Criticism section, Robert Bruegmann joined the faculty in the fall term to teach two subjects on American architecture. In the spring term, Professor Choay from the Institut d'Urbanism at the University of Paris taught two subjects to graduate students in HTC; Professor Emeritus Soltan from Harvard taught a seminar titled "Main Trends in Modern and Contemporary Architecture."

Visitors in the S.M.Arch.S. program were Professor Paolo Ceccarelli from the University of Venice, who taught "Theory of City Form" and an advanced seminar on issues of city design, and Constance Perin, Senior Policy Analyst from the Transportation Systems Center, Cambridge, Massachusetts, who offered a seminar on the social and cultural geography of suburbs. Professor Peter McCleary, former Head of the Department of Architecture at the University of Pennsylvania, was Visiting Professor in the fall term, teaching graduate subjects in Building Technology.

Professor Chester Sprague was on leave this academic year, teaching and conducting research at UCLA. Professor Edward Allen was also on leave for the year. Professor Waclaw Zalewski took partial leave in the fall term to travel to Poland. Professor Smith traveled to Spain during his leave in the spring. Professors Kanda, Slattery, and Tremaglio were also on leave.

Professor Bryan (with Michael Kwartler, Renssalaer Polytechnic Institute, and Ray Masters, Penn State) was awarded a 1982 Progressive Architecture "Urban Design and City Planning" Citation for work on development of a new zoning regulation for midtown Manhattan.

Professor Robbins led a two-week seminar, "Theory, Method, and Criticism in Architecture," for the Faculty of Architecture at the College of Architecture of Chile, Santiago, in June 1982. Professor Howell was a speaker at the twelfth International Congress of Gerontology, Hamburg, Germany, presenting a paper titled "Determinants of Housing Choice Among the Elderly," based on her current research.

Professors Beinart and De Carlo served as joint editors of a new international journal, *Space and Society/Spazio e Societa*, published by MIT Press and Sansoni. The first issue appeared in May 1982.

Professor Beinart was re-elected for a second two-year term as President of the International Design Conference in Aspen.

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JULIAN BEINART

Department of Urban Studies and Planning

The selection of a new Head for the Department of Urban Studies and Planning (DUSP) occupied much of our attention during the fall semester. Professor Gary Hack will become Head in August 1982, replacing Professor Lawrence Susskind (who will be returning to the faculty after serving four years as Associate Department Head and four years as Department Head).

In addition to the normal academic year activities, the Department devoted a great deal of energy to the recruitment of three new junior faculty members, to the further modification of the master's degree core curriculum, to winning MIT approval for substantial revisions and a name change for our undergraduate degree program, and to the preparation of a major funding proposal to support the long-term development of the Department. On November 16, 1981, the School held a day-long symposium honoring former Dean William Porter. On March 11 and 12, 1982, the Department met with a subcommittee of the School's Visiting Committee for an overall review of Departmental activities.

Undergraduate Program

A year ago the DUSP proposed changes in its undergraduate urban studies (S.B.) curriculum to reflect the Department's increasing focus on professional preparation and applied social science (as opposed to urban studies) at the undergraduate level. While some of our prior curriculum remains intact, two new required analytic subjects (statistics and a data analysis laboratory) have been added, along with a required year-long seminar emphasizing the uses of social science in formulating and analyzing planning problems and implementing public policy. Our proposed curriculum changes sailed through the appropriate MIT communities, but the changes in the title of the degree that we proposed met with stiff resistance. Our original

suggestion had been to change the title from Bachelor of Science in Urban Studies to Bachelor of Science in Planning and Applied Social Science. The term "urban" no longer seemed broad enough to encompass our regional and environmental planning interests. The term "studies" seemed too passive and failed to reflect the interventionist roles for which we are preparing our students. While the phrase "applied social science" captured the sense of our mission, it triggered a variety of defensive reactions and raised broader questions about the scope of social science teaching at MIT that were not about to be resolved at this time. Ultimately, Dean John de Monchaux proposed to the Academic Council and the MIT faculty that the S.B. title in Course XI be changed to Bachelor of Science in Planning. The MIT faculty agreed.

The vast majority of undergraduates enrolled in Course XI are, again this year, non-DUSP majors taking DUSP subjects as unrestricted electives or as part of their Humanities, Arts, and Social Sciences Requirement. Enrollment in the Department's five Humanities Distribution subjects also remains high. The number of students selecting the Department as their Field of Concentration has remained steady. In fact, we already have a dozen students from the Class of 1983 signed up for next year.

The number of DUSP undergraduate majors remains small, approximately a dozen. Our enrollment of majors has dropped in recent years along with the fraction of MIT undergraduates choosing some branch of social science as a major -- this fraction is now down to only five percent Institute-wide. This raises serious questions about the current tilt in MIT's admissions policies and the apparent underutilization of undergraduate teaching resources in MIT's social science departments.

Professor Joseph Ferreira, who headed the undergraduate program this past year, will be on sabbatical in 1982-83. Professor Aaron Fleisher will assume responsibility for the undergraduate Course XI program next year.

Professional Degree Program

The Master in City Planning (M.C.P.) Committee, headed again this year by Professor Langley Keyes, devoted a great deal of attention to 1) further revisions in the professional core curriculum; 2) analysis of the results of our one-year experiment with a shortened version of the master's thesis, 3) exploration of the Department's commitments to international planning and the needs of non-US professional degree candidates, and 4) a review of the Department's Activity Areas (or M.C.P. specializations).

The M.C.P. Core Course Review took the form of weekly meetings of the "Core Course Committee" -- a group of interested students and faculty responsible for teaching the "new" core. The Committee's work was carefully prescribed in the fall of 1981: to develop the specifications for and working relationships needed to implement a "revised core" in the fall of 1982.

Coordination of the complex connections among the core subjects, which has been one of our goals for years, seems to be close at hand. In addition to detailed discussion of how subjects will be taught and how they will relate to each other, the Core Committee spent a great deal of time discussing the role that small group projects will play in the curriculum. New case studies were developed to help focus these small groups. The cases are based on development and planning experiences in the city of Boston.

Despite changes in the current core subjects produced by the core review process, the Committee did not suggest a radical restructuring of the core, but rather urged a concerted effort to carry out the goals that had originally been set but never implemented.

The experiment proposed last year with the shortened version of the master's thesis was carried out this year under the close scrutiny of Dr. Mark Schuster. With the term completed, we can now evaluate the results. In general, the shortened thesis provided a valuable option for many of the 16 master's degree candidates who chose it. They substituted additional course work for the traditionally lengthy thesis. If anything, the people pursuing the full 30-unit (as opposed to the new 12-unit) thesis worked even harder and wrote more extensive theses than in the past. We await a complete report on the short thesis option from the M.C.P. Committee.

For some time, the M.C.P. Committee has been concerned about two interrelated issues regarding planning in international settings: to what extent can we and should we offer a specialization for American-born people who want to plan for Less Developed Countries (LDCs), and how much can we or should we offer to individuals from those countries that will be relevant to their needs as planners after they return home. Following extensive discussions, the M.C.P. Committee reaffirmed the Department's commitments both to American-born planners who want to work overseas and to those planners from LDCs who look to MIT as a place where they can acquire valuable professional planning skills.

Activity Areas have become an important organizing device for the Department in recent years. The number, name, and content of these areas of specialization, however, are a constant topic of debate. In an effort to establish once again the "reality" of the existing Activity Areas, the M.C.P. Committee took a hard look at the faculty and curriculum commitments in each Activity Area. An extensive investigation led by Professors Lisa Peattie and Hassan Minor provided the basis for a series of heated discussions. The outcome was a shared view that while some of the Activity Areas are "thin," the concept of Activity Areas provides a useful way for students to organize their involvement in the Department.

After four years as Head of the M.C.P. Committee, Professor Keyes is turning over responsibility to Professor Tunney Lee.

Ph.D. Program

Despite rising tuition and other increasing costs, the Department received about the same number of applications for the Ph.D. program as in the past, and as of late May 1982, the entering class for the fall of 1982 appears to be larger than expected due to an especially high rate of acceptances. Out of approximately 80 applications, 25 students were offered admission on the assumption that approximately 15 or 16 would attend. By May, 20 new Ph.D. candidates had notified the DUSP of their intention to enroll in the fall -- this in the face of repeated and explicit Departmental statements concerning the lack of financial aid.

Regional planning and economic development remain at the top of the list of interests of the incoming class with somewhat less focus than in the past on housing, environmental policy, and social policy.

As a compliment to the Ph.D. program, four of the six 1982-83 dissertation fellowships awarded by the MIT-Harvard Joint Center for Urban Studies were offered to DUSP doctoral students currently writing dissertations. It is rare that a single department at one university captures so many of these prized fellowships.

Professor Robert Fogelson will continue to serve as Head of the Ph.D. committee in 1982-83.

SPURS

The Special Program for Urban and Regional Studies (SPURS) admitted 14 applicants from 14 separate countries for the 1981-82 academic year including, two Fellows from Africa, three from Asia, five from Latin America, three from the Middle East, and one from Europe. Unlike previous years, all of the Fellows held middle management or agency head positions in the public sector. Four held positions as directors, two as chiefs of their agency/department, and one as general manager.

The academic background of the Fellows reflected a wide range of disciplines: three had degrees in economics, two in planning, four in engineering, three in architecture, one in business, and one in education and psychology. Eight Fellows are returning directly to their countries to take up their previously held positions. The remaining six Fellows will pursue further studies at MIT.

Three visiting scholars were associated with SPURS during the academic year: Professor Giovan Francesco Lanzara and Professor Gidomenco Amendola, both of the University of Barin in Italy, and Dr. Sachihiko Harashina of the Tokyo Institute of Technology in Japan.

The SPURS luncheon series continued to attract top speakers from all over the world. The Tuesday evening seminars provide Fellows with an opportunity to evaluate each other's work.

As has been customary over the past few years, the SPURS Fellows made their annual trip to major development agencies in New York and Washington, DC. Several fellows undertook internships at international development agencies in Washington during the spring term. For the first time, two joint meetings of the SPURS Fellows and the Community Fellows were held. These meetings were aimed at identifying common community development models from the perspectives of developing countries and central cities in the US.

SPURS accepted six Hubert Humphrey Fellows this year. Professor Ralph Gakenheimer represented SPURS at the Humphrey Program Coordinators' Seminar held in New York in June 1982. Alan Strout filled in as Acting Director of SPURS while Lloyd Rodwin was on sabbatical.

Community Fellows Program

The Community Fellows Program held its traditional August orientation program again this year, to provide new Fellows with an opportunity to meet each other in an informal setting and participate in specially organized seminars on energy policy, economics, nutrition, leadership, management, and research methods. Peak enrollment in the Fellows Program reached 11 this year (two Fellows had to leave early in the year because of family or personal illness). The Program's Tuesday evening seminar series continued to attract top officials and leading experts in community development. One of the highlights of the year was a trip to Cuba organized by several current and former Fellows and CFP Director, Mel King.

During the spring semester, the Fellows organized a set of seminars aimed at bolstering the exploration of topics of special interest to the Fellows. Once again, topnotch outside speakers volunteered to participate. Many of this year's Fellows are already moving to implement the recommendations or results of the projects they undertook during their year at MIT.

Other Accomplishments

The Department of Urban Studies and Planning received a total of 287 applications from prospective students. Of the applications received, 209 were for the Master of City Planning program and 78 for the Ph.D. program. A total of 53 applicants were offered admission to the M.C.P. program (with a waiting list of 20). Three of the 53 are currently enrolled in SPURS. Forty-six students will be entering the M.C.P. program. Two will be joint degree candidates and two will be joint law/planning students with Boston-area law schools.

A total of 27 applicants were offered admission to the Ph.D. program (with a waiting list of 8). Twenty-two students will be entering the Ph.D. program; two are being readmitted. About 10 percent of the incoming M.C.P. class is from outside the US; almost 25 percent are minority. Five percent of the incoming Ph.D. class are minority; 10 percent are foreign. These acceptance ratios are nothing less than phenomenal when compared with other planning schools in the US and startlingly good when compared to other MIT graduate degree programs. The implication is that the level of financial aid offered by the DUSP (approximately 50 percent of our graduate students received the equivalent of tuition support, and 50 percent about one-half the cost of tuition), is sufficient for us to compete for students with the top planning, public administration, public management, and public policy schools in the US.

The Department was active this year in the work of the National Accreditation Task Force of the Association of Collegiate Schools of Planning (ACSP). ACSP moved several steps closer to approving a formal system of graduate school accreditation. Final action on this matter will be taken in the fall of 1982. ACSP also held its first national conference for planning educators completely independent of the regular annual meeting of the American Planning Association. The ACSP sessions, held in Washington in the fall of 1981, were a tremendous success. Almost 20 percent of the 800 planning educators in the US were present at the conference. ACSP recently initiated a new *Journal of Planning Education and Research*, in which MIT's Department of Urban Studies and Planning faculty and students have been involved.

The DUSP Postdoctoral Fellows program attracted an extraordinary group of 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. The Postdoctoral Fellows program is supported by a gift from Alan M. Voorhees, a DUSP alumnus.

Research

DUSP faculty were principal investigators this past year on research projects totaling more than $500,000. This does not include projects administered through the MIT-Harvard Joint Center for Urban Studies or other non-school laboratories or centers. Research sponsors included the National Science Foundation, US Department of Health and Human Services, Agency for International Development (AID), US Departments of Energy, and Housing and Urban Development, US Environmental Protection Administration, and a number of local foundations. Funded faculty research clustered under four headings: intergovernmental fiscal relations, environmental policy analysis, multi-regional economic policy analysis, and environmental programming. Forty-one graduate students received research assistantships through the DUSP. Total aid to graduate students (from all sources) exceeded $800,000 this past year.

Personnel Changes

There was one promotion this year. Lawrence Bacow was promoted from assistant to associate professor. There were no tenure cases reviewed. There was one departure from the faculty: Professor Hassan Minor will be leaving the DUSP faculty July 1, 1982.

Three new assistant professors have been appointed for the coming year. Dr. Lynn Sagalyn has been recommended for appointment as Assistant Professor of Housing and Real Estate Development; Dr. Yohel Frexias-Camayd has been recommended for appointment as Assistant Professor of Planning and Community Psychology; and Dr. Merrie Klapp has been recommended for appointment as Assistant Professor of Planning and Environmental Studies. All three replace faculty members who left over the past several years. A fourth appointment in the field of public management has been deferred for one year.

Problems

The Department is in desperate need of additional space for faculty and student offices. We can no longer provide adequate accommodation for research, teaching, or study. The Department has raised this issue over and over again for several years. Something must be done to relieve the terrible overcrowding of offices and to accommodate research activities. The faculty are now forced to house research projects off campus -- severing already-tenuous relationships among members of the faculty and student body. Without additional library space for research staff, student and staff researchers will be forced either off campus or to other parts of the campus, undermining the sense of community that it has taken more than a decade to build. Additional space in Building 11 is the only remedy in sight. We hope that the MIT administration will find a way to help us out.

The Department has prepared a major, three-year financial development plan. In light of continued Federal cutbacks (for research, student aid, and curriculum development) in our field, foundation and private support are more important than ever. We need special assistance to raise the $4 to $5 million needed to adequately endow our non-degree programs, internships in the public sector, student aid funds, and faculty chairs.

LAWRENCE SUSSKIND

Laboratory of Architecture and Planning

The year 1981-82 was one of continued growth for the Laboratory of Architecture and Planning (LAP). The majority of the School's researchers base their research activity in the LAP. While the LAP continues to support the initiatives of individual faculty members, it concentrates on promoting initiative to bring together faculty to pursue research topics within our own agenda.

The research and special programs conducted through the LAP serve its three broad objectives of 1) furthering state-of-the-art practice and teaching in the fields of architecture and planning; 2) linking the School with the activities of practice; and 3) encouraging research about areas of emerging concern to society and the profession.

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

A major achievement for the LAP this year was the launching, with the School of Engineering and the Energy Laboratory, of the new Joint Program for Energy-Efficient Buildings and Systems. The work of the Joint Program 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 provide administrative services for the program. We are now developing an advisory board drawn from industry and practice.

This year the Department of Architecture and the LAP, with support from the Grunsfeld Foundation (matched by MIT funding) began a research incentive program for design and research faculty. The current support, which will last for three years, will seed considerable research in all topics of concern to the architectural profession.

Research

The impact of Telecommunications Technology on Settlement Patterns project completed exploratory efforts to define a longer-term research agenda. Professors Julian Beinart and Edward Robbins are the principal investigators. 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 Minority Business Formation Growth and Failure Rate Study analyzed the processes by which minority businesses expand or fail and looked for significant differences between minority businesses and other businesses. Dr. Birch is the principal investigator, and the work is funded by the Small Business Administration.

The Community Energy Impact Study continues to investigate the ways in which energy demands are affected by the changing structure of the US economy and the responses of households and businesses to that structure. Dr. Birch is the principal investigator, and the work is funded by the Department of Energy (DOE).

The Planning Urban Infrastructure for Secondary Cities in Egypt project continues to explore 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 analyzed 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 the Network was administratively based for two years 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 and the new Crystal Pavilion addition, constructed on the MIT campus, continue 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 is funded by the DOE 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 is in collaboration 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 private industry.

The Impact: 2 1/2 program is carried out by an inter-university consortium directed by Professor Lawrence Susskind. The program aims to monitor the long-term impact of the statewide program of tax and spending reduction authorized by Referendum Proposition 2 1/2 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 Sub-seabed Disposal of High-Level Radioactive Waste project analyzes the institutional obstacles to sub-seabed disposal of high-level radioactive waste. Alternative management systems are being designed for the long-term operation of a disposal program. Professor Susskind is the principal director of the project which is funded by the SANDIA National Laboratory.

The LAP serves as the overall administrative 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, student travel grants, 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. Professor 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 brings 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. Professor Porter is the principal investigator and LAP Director Joroff is the project coordinator.

The Architectural Case Studies program prepared 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-cum-consultation services to institutions and organizations which seek to adapt physical environments to meet the special needs segment of the population. 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 uses 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 1981 were: Realities of Historic Preservation (R. Neiley); The Planning Process (T. Nutt-Powell); Environmental Design and Planning (M. Elliott); Passive Solar Energy -- Tools for Design Application (H. Bryan); Daylighting (H. Bryan); Design in Islamic Countries (W. Porter); and Improving Professional Effectiveness (W. Ronco).

This year the Continuing Education Program presented its first overseas program. A housing course was presented in Karachi, Pakistan, in collaboration with the Aga Khan Program for Islamic Architecture. This venture, which attracted 85 practitioners and educators, was highly successful and will serve as the prototype for future overseas courses.

In August 1981, for the third 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 Architecture and Engineering played a leading role as faculty of the Institute. Representatives from more than three-quarters of the nation's architectural schools have now attended this MIT-based Institute.

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 offers almost 50 major titles, including those produced by the MIT Joint Program for Energy-Efficient Buildings and Systems. *The Environmental Impact Assessment Review*, published by Plenum Press, edited by LAP staff under the direction of Professor Susskind, completed its second year of publication. Professor Porter, with associates from MIT, the University of California at Berkeley, and the MIT Press, successfully market-tested a new journal about environmental design, *Places*. Funded by the National Endowment for the Arts, the project is administrated by the LAP. This year the LAP concluded an agreement with the SAR group in Holland to coedit an international housing journal. Professor Nabeel Hamdi will be the LAP-based editor.

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. LAP Research Affiliate Thomas Piper directed an hour-long documentary, based on the LAP-based project, about the impact of the Massachusetts tax containment law, Proposition 2 1/2. The LAP is also the home for the *Impact: 2 1/2 Newsletter* which reports monthly to Massachusetts officials and citizens about the impact of this law on the Commonwealth's cities and towns.

Staff

Several new research staff were appointed to the LAP this year. Dr. Sachihiko Harashina from Japan's Environmental Protection Agency was a visiting scholar. Leland Neuberg and Felicia Clark, an international planning consultant, joined the staff as research affiliates. Argie Staples, Gwinn Shick, and Patricia Claffey joined the LAP's support staff. Continuing on the LAP's core staff were: Donna M. T. Herlehy, LAP assistant director; senior research scientist

David L. Birch, principal research scientists John Klensin and Mona Serageldin; research associates Rebecca Packard and William Parsons; administrative staff Margaret B. Sevcenko, and administrative assistant H. Sharon Trohon. Bernard Spring, Thomas Piper, and Donna McDaniel continued as research affiliates of the LAP. Dr. William Ronco continued to manage the LAP's Continuing Education Program.

In addition to LAP-based research work, several members of the LAP staff were busy with professional activities. Dr. Birch's work about the job generation of small business (for which he was awarded the Business Administration's Researcher of the Year Award, 1980) received considerable coverage in the business press, including several feature articles. Dr. John Klensin assumed the chairmanship of the American National Standard Institute's technical committee for PL/1 standardization. LAP Director Joroff was elected chairman of the board and president of the Architectural Research Centers Consortium (ARCC) for the second consecutive year; in this capacity he chaired a workshop to develop a research agenda for the new building science program of the National Science Foundation. In the past year he also became a member of the editorial board of the Association of Collegiate Schools of Architecture's *Journal of Architectural Education*, a member of the advisory board of the Boston Architecture Center's Energy Design Institute, and an incorporator and member of the board of the Adaptive Environments Center.

Collaborative Arrangements

The LAP continues to extend its breadth of involvement in projects through collaboration with a variety of organizations. 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 25 major university-based research centers. The LAP is one of a dozen university participants in the Impact: 2 1/2 project as described above. The LAP is also one member 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.

After four consecutive years of the LAP acting as host of the Association of Collegiate Schools of Architecture's (ACSA) Summer Energy Design Institute for architectural faculty, the LAP and ACSA have formally agreed to collaborate on an annual summer institute about teaching technology in schools of architecture. The summer 1982 course will conclude our series on energy-conscious design; the summer 1983 course will focus on computers and architecture.

The LAP is an active participant in MIT's efforts to foster collaborative research and education programs with the University of Tokyo. Professors Rodwin of the Department of Urban Studies and Planning, Howell of the Department of Architecture, LAP Director Joroff, and several students worked with colleges in Tokyo to begin framing projects of mutual interest. Professor Itoh, chairman of the Urban Engineering Department, visited MIT to explore potential topics for joint research. The LAP is also coordinating the School's collaborative building and energy research with the Technical University of Berlin. We hosted a two-month visit of TUB architecture faculty and students in the fall of 1981.

The LAP is an associate member of the Rome-based International Conservation Center of Rome (ICCROM), and we are exploring opportunities for collaborative teaching about neighborhood preservation in international settings. The LAP is also now planning professional seminar programs about energy conservation and buildings with the Boston Architectural Center, the Swedish government, and the Danish Board of Trade. A seminar series about public/private partnership for urban revitalization is also being planned as a collaborative venture of the LAP, the Boston Private Industry Council, and the Committee for Economic Development.

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 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.

The LAP is further increasing its networks for collaboration on all of its activities as a necessary strategy to cope with the difficult economic situation for research funding. We have begun to increase the proportion of support that we received from industry and foundations. The problems imposed both by Federal funding cutbacks and by more stringent governmental regulations continue to be difficult for us. We shall continue to work with the MIT administration to deal with these issues as they arise.

MICHAEL L. JOROFF

School of Engineering

Academic year 1981-82 is characterized as a year of growth, building, and changes within the School of Engineering.

Counter to expectation that undergraduate enrollment would level off as of this year, the student body increased by 4.6 percent over last academic year. Large increases were noted in the Departments of Aeronautics and Astronautics, Materials Science and Engineering, and Chemical Engineering.

Graduate enrollments have decreased very slightly, to a total enrollment of 1,844. The academic community has been concerned for some time about the decreasing numbers of US students enrolled in Ph.D. programs of study. This "seed corn" problem has direct linkages to our educational programs with serious consequences if it persists. Several leading members of the US industrial community have also become sensitive to the problem and its implications. As a result, this year a number of organizations have planned, with MIT assistance, a variety of fellowship and forgiveable loan programs aimed at encouraging graduate students to pursue teaching careers. These funds are typically directed towards US citizens who have a demonstrated proficiency and interest in teaching. Funds have already been received from such organizations as the ARCO and Exxon Foundations.

Engineering Internship Program (EIP)

Company and student response to the Program remains strong. The spring of 1982 saw 163 sophomores apply for admission to the EIP, up sharply from the 100-110 students who applied in the two preceding years. From this number, 38 students were selected to start in the internship class for 1982. This was somewhat lower than expected, and is directly related to the downturn of some sectors of the US economy. The EIP continues to be highly regarded as a link between industry and MIT. Although a number of firms were not in the financial position to support a student this year, all expressed the desire to remain on the EIP membership list. Two new companies joined the EIP for 1982: Charles T. Main, Inc., of Boston and the Boeing Military Airplane Company of Wichita, Kansas. In total, 110 students will be enrolled in the Program this year.

John Martuccelli, director of the Program, answers a sizeable number of requests from other universities for information on the design and concept of the EIP. There was a noticeable need for information on the graduate phase of the Program, reflecting interest on the part of the cooperative education community in the expansion of this mode into the graduate school.

Management of Technology

In June 1982, six students of the first graduating class in the Management of Technology received the Master of Science in the Management of Technology. The Program, administered jointly with the School of Management, is designed to prepare engineers as managers of technical functions and organizations. Extensive curriculum development has taken place over the past 18 months, and to the Program's credit, eight new subjects have been generated, by both Engineering and Management faculty. These include, among others, technology planning, marketing and manufacturing interfaces with technology, cases and projects in engineering management, and managing professionals. The Program will remain at its pilot-size enrollment for the second year. It will gradually be scaled up to the full program size of 40 to 50 students per year.

School Appointments

During the past year, Professor Ira Dyer asked to be relieved of the duties of Department Head of Ocean Engineering, and returned to full-time faculty duties. Professor Chryssostomos Chryssostomidis served as Department Head (Acting) from September 1981 through mid-January 1982. During this period a faculty search committee recommended Professor T. Francis Ogilvie of the University of Michigan for the position of Professor and Department Head. The action was endorsed by the Dean and the Administration, and Professor Ogilvie joined the faculty in mid-January 1982.

Professor Walter S. Owen, Head of the Department of Materials Science and Engineering, asked to be relieved of that responsibility as of August 31, 1982. He will return to full-time faculty responsibilities, and will lead the Department's teaching and research efforts in physical metallurgy. Merton C. Flemings, Toyota Professor of Materials Processing and Director of the Materials Processing Center, will assume the post of Department Head effective 1 September 1982.

Professor Herbert H. Richardson has been named Associate Dean of the School of Engineering, and will assume the post effective 1 September 1982. Professor Richardson, who has been Head of the Department of Mechanical Engineering since July 1, 1974, will relinquish that position on August 31, 1982.

GERALD L. WILSON

Department of Aeronautics and Astronautics

The Department is healthy as measured by two of the most obvious criteria: the number of students enrolled and the dollar volume of research. There were 91 in our sophomore class (compared to 75 a year ago) and there was a sudden jump of 30 in the number of graduate students, bringing that total to 180. Research dollars in the Departmental laboratories rose from $4 million to almost $6 million. Despite current problems encountered by the US manufacturers of commercial transport category aircraft (lack of orders from the airlines and growing foreign competition), there is still much interest among the young people of this nation in the education which we provide. In fact, every launch of the Shuttle, the nation's space transportation system, brings a few more students into our Department. Enthusiasm is great among students and faculty because the high technologies required to build more fuel-efficient aircraft and exploit the potential of outer space are still very exciting and challenging.

There is some trauma associated with the increased number of students. Our introductory-level subject, Unified Engineering, is taught by a team of faculty, and at the beginning of the fall term there were 108 students (composed of juniors as well as a few students from other departments, plus the basic sophomore population). We do not have the resources to split this subject into two sections. The classroom, Room 35-225, in which the lectures are given, is ill-equipped (poor-quality blackboards) and ill-shaped (steep amphitheatre) for our most important subject. Another requirement for our undergraduate degree is the Experimental Projects Laboratory, and the large numbers present problems because physical space is inadequate, and experimental equipment is generally not of modern standards.

The addition of a floor in the basement of Building 33 did not materialize by the end of summer 1981 as planned. We have again been promised that these kinds of renovations will take place during the summer of 1982, although the pace of the real decisions which have to be made is agonizingly slow.

A related space problem is that the Department decided to vacate Building W91 except for space occupied by experiments being conducted by Professors Karl Ingard and Sheila Widnall. This means that all the equipment needed to operate the supersonic wind tunnel has been put on the market; the Department hopes to realize enough monies from the sale of the surplus equipment to improve facilities closer to Building 33. The relinquishing of Building W91 makes the renovation of the basement in Building 33 all the more important for our program.

The increase in research funding was not uniformly distributed over the entire faculty. There are still faculty and students who require research support. National priorities are being redirected, and new guidelines are being promulgated. Another factor, as viewed by our potential sponsors, is the relatively high cost of research at MIT. The stipend for a graduate research student is about $2,000 per month, and costs of computer time, laboratory specimens, etc., are additional. A research program involving one faculty member, two graduate research assistants, some technical support staff, supplies, and computers, requires about $150,000 per year from the sponsor. But there are very exciting opportunities in the offing if we can position ourselves advantageously. The most urgent need is for computers: to run experiments, acquire and massage data, crunch numbers, and make report writing a joyful endeavor. There is also a need for large pieces of equipment, some of which can be purchased and some of which need to be designed and fabricated on campus. We intend to study these needs and opportunities during the coming year.

Undergraduate Program

Undergraduate enrollment continues to increase and the trends are indicated in the following table:

	1977-78	1978-79	1979-80	1980-81	1981-82
Sophomores	39	53	70	78	91
Juniors	45	37	47	70	73
Seniors	29	45	41	55	62
Totals	113	135	158	203	226

Six of the seniors chose the Avionics Option for their undergraduate program, and nine of the juniors have elected the same option.

Two new undergraduate electives were added to the list of subject offerings. These were 16.291 Manufacturing with Advanced Composite Materials, developed by Assistant Professor Paul Lagace; and 16.81 Space Flight Engineering, developed by Assistant Professor David Akin. Additionally, the subject 16.06 Space Gas Dynamics has been modified by Professors Leon Trilling and Harold Wachman so that students whose outlook is astronautics rather than aeronautics can replace the traditional requirement of 16.02 Aerodynamics with 16.06.

Under the leadership of Professor Emmett Witmer, the Undergraduate Committee discussed the matter of minimum academic requirements. Many members of the faculty have been concerned that a small number of students managed to reach their later undergraduate years with a consistent record of poor performance in professional subjects. Hence, the Department was awarding degrees to people with embarrassingly marginal-to-deficient professional qualifications. As a result, the Department faculty voted to accept the Undergraduate Committee recommendation that Course XVI students, beginning in the fall of 1982, will be required to earn a grade of C or better for all prerequisite subjects. A student who does not earn at least a C must repeat the subject with a grade of C or better, or remedy the deficiency by an alternative, approved procedure.

In Course XVI, as in the other engineering departments, there is a continuing discussion on the use of computers for undergraduate engineering education. There are proponents for giving each undergraduate his or her own personal computer, but obviously, we do not have the resources to make this possible. Another proposal is to give essentially unlimited connect time on a terminal to our undergraduates, so that they could "hack" to their heart's content. This also requires more resources than are available. Neither of these proposals address the real issue of how computers can enhance undergraduate engineering education. The Department provides some resources so that the undergraduate does have access to computers. Additionally, many, if not most, of the Departmental research laboratories have computer assets. For example, the Gas Turbine Laboratory owns a Perkin-Elmer, as well as four DEC systems. The Technology Laboratory for Advanced Composites owns a PDP 11/34; the Flight Transportation Laboratory has been loaned a VAX; the Fluid Mechanics Laboratory owns three Apple II personal computers; and the Space Systems Laboratory possesses TRS computers as well as an IBM personal computer. Many of our undergraduates

join these laboratories through Undergraduate Research Opportunities Program (UROP) projects and in this way, learn how to use computers. Thus, our undergraduates gain literacy with respect to computers even though we do not require our students to take specific subjects in computers or programming. But again, this is not computer-enhanced education. We have decided, on a very limited scale, to embark on a program called Computer Enhanced Engineering Education, (CEEE). During the coming year we expect to address CEEE rigorously and vigorously.

The subject 16.61 Microcomputer Laboratory was offered for the first time during the past academic year. Only 12 students could be accommodated during each of the two terms. We were fortunate during the past year in having a graduate student, Stanley Sasaki, who, under the supervision of Professor William Widnall, literally created the laboratory and the experiments. Unfortunately, he graduated and has departed. This kind of a laboratory is important to the Department because the use of microprocessors to control mechanical systems now pervades all of aeronautics and astronautics; even structural forms are being actively controlled by microcomputers controlling sensors and actuators. As in the case of computers, our undergraduates, through UROP experiences, learn how to apply microcomputers. With each class containing 90 or more students, a laboratory which accommodates only 12 students will have only limited impact. Additionally, this field is advancing so rapidly that equipment becomes obsolete in a very short time. The solution is to somehow connect this laboratory to the research activities which require microcomputer control.

The Department's required subject Experimental Projects Laboratory will be studied during the summer of 1982. Currently, the mode of operation which was adequate for classes of 40 students is clearly inadequate for classes of 90 students. This subject is still educationally beneficial for our undergraduates, due only to the efforts of a relatively small number of faculty and staff who have assumed most of the load inherent in the laboratory subjects. The present mode of operation relies on outside funded research activities; in many respects, this is the best experience for the students. A number of faculty never participate in this course, one of the key subjects for our students. Additionally, there are the ever-present problems of overcrowding of available space, the scarcity of modern instrumentation, and the access to certain research facilities -- such as the Wright Brothers Wind Tunnel, which levies a fee of $100 per hour for all users.

Graduate Program

As noted earlier in this report, there was a more than quantum jump in the number of graduate students enrolled in the Department during the past academic year. One hundred of these were research assistants, four were teaching assistants, and 20 were fellowship recipients. There were 211 applications, which is the largest in recent memory, for admission in the fall of 1982. Admission was offered to 110, and financial aid was offered to 45. The projection is that 60 will enroll, and that the total number of graduate students will be 187, a slight increase over the 180 for the year ending June 1982. There will be 13 women, 4 minority students, and 54 international students. There will be 58 doctoral candidates, and 129 will be enrolled in the S.M. degree program.

During the past year, the Department acted on the recommendation of its Graduate Committee and revised the requirements for the degree S.M. in Aeronautics and Astronautics, so that of the 66 required units, 42 must be in 'A' subjects, of which at least 21 units must be in the Departmental subjects.

The Doctoral Committee, chaired by Professor Manuel Martinez-Sanchez, administered the qualifying examination to 35 students. Of this number, 26 were admitted to the doctoral program.

Three new subjects were added. These are: 16.055 Unsteady Fluid Mechanics by Professor Eugene Covert; 16.321 Fault Tolerant Control Systems I, and 16.322 Fault Tolerant Control Systems II by Professors Wallace E. Vander Velde and Bruce K. Walker. These latter two subjects are being developed in cooperation with the Draper Laboratory under a grant from the Hertz Foundation. The offerings in the field of filamentary composite materials were expanded to a two-term sequence consisting of 16.291 Design with Filamentary Composite Materials and 16.293 Advanced Topics in Filamentary Composite Materials by Professor James Mar. A number of offerings were dropped: 16.15 Advanced Flight Vehicle Stability and Control, 16.253J Advances in Fracture Research, 16.29 (replaced by 16.291), 16.353 Visual Signals and Systems, 16.43 Strapped-Down Inertial Systems, and 16.703 Introduction to Aerospace Management.

The sudden influx of additional graduate students, coupled with the increase in tuition and the impact of inflation, has created a problem of thesis supervision. The student who has a research assistantship also has the principal investigator of the research contract as thesis advisor. Some of the students can attach themselves to one of the Departmental laboratories, and in this way obtain thesis supervision because the resulting thesis is a contribution to the goals of the laboratory. For the other students who do not have this kind of relationship, the quality of thesis supervision is not the same. This is a growing concern and one which will be addressed by the Department's Graduate Committee, chaired by Professor Wachman.

Research

Research funding for which the Department faculty were the principal investigators reached a total of almost $6.6 million for fiscal year 1982. Most of this funding is under the direct control of Departmental laboratories. There is some funding managed by the Research Laboratory of Electronics (RLE), and small amounts from Health Sciences and Technology (HST) and the Energy Laboratory. By far the largest laboratory in the Department is the Gas Turbine and Plasma Dynamics Laboratory, which is headed by Professor Covert. Their total funding is in the neighborhood of $1.9 million for fiscal year 1982.

During the past year, the headquarters staff of Donna Savicki, administrative officer; Ping Lee, administrative assistant; Helen Raine, administrative secretary; and Anne Maynard and Katherine Palazzolo have, in addition to their normal academic responsibilities, taken on the extra tasks of administering research contracts for a number of the smaller Departmental laboratories: the Technology Laboratory for Advanced Composites (TELAC); the Space Systems Laboratory (SSL); and the Aeroelastic and Structures Research Laboratory (ASRL), which includes the Wright Brothers Wind Tunnel. This has made sense to us (and has saved money) because Department headquarters already takes care of the payroll for all of the graduate students, already must keep track of faculty salary allocations and, when faculty fall short of research money, must cover the shortfalls. Additionally, these smaller laboratories could not justify the costs of administrative officers on their limited budgets. For these reasons, the Department has decided to centralize the administration for all except the largest laboratories in headquarters.

The Department decided in the fall of 1981 to disband the Aerophysics Laboratory, and to vacate Building W91 (originally called the Naval Supersonic Laboratory), except for the space occupied by experiments being conducted by Professors Ingard and Widnall. In 1978, the supersonic wind tunnel was operated for a total of 22.8 hours. There has been no operation of that tunnel since that time, nor does there appear to be any requirement for supersonic research. The operation of the supersonic wind tunnel is very costly, and we cannot envision any source of funding which could enable us to maintain the skills required to operate it. Our conclusion, regrettably (and, despite the memories of past achievements), is that the best course for the Department is to relinquish that facility. We hope that the sale of the equipment in W91 will be used to upgrade the air-moving capabilities of facilities closer to Building 33. Already accomplished is the consolidation of the best of the machine shop equipment in Building W91 with the Department's new centralized machine shop in Building 31.

A new aerodynamic facility has been added to the Department's experimental capabilities, and an old one has been measurably improved. The new facility is the low-turbulence wind tunnel which physically arrived on the scene in the spring. Professors Joseph Haritonidis, Marten Landahl and Widnall will use the tunnel for fundamental studies related to turbulent boundary layers, drag reduction, airfoils, and flow stability phenomena. Calibration and initial shakedown operations will take place during the summer of 1982, and research will begin in the fall of 1982. The old facility -- the Wright Brothers Memorial Wind Tunnel (dedicated in September 1938) -- has undergone the first phase of a modernization program that allows for aircraft research and development testing. An automatic-moment balance system has been installed and connected to a dedicated computer. This first phase was made possible through a $50,000 gift from Fairchild Republic Company of Farmingdale, Long Island. The next phase includes enlarged computer capability and input/output peripherals, as well as an increase in the attitude capability of the models. This, too, will be made possible by a gift from Fairchild Republic. Professor Judson Baron has been instrumental in bringing about these improvements.

A new research entity, the Computational Fluid Dynamics Laboratory, has been formed under the leadership of Professor Earll Murman.

The Space Systems Laboratory, under the leadership of Professor Rene Miller, is continuing its pioneering research on the productivity of humans in space, using both the MIT swimming pool and the large Neutral Buoyancy Facility at the Marshall Space Flight Center (MSFC). During most of January and again in June 1982, there has been a team of students under the leadership of Assistant Professor Akin conducting experiments at MSFC. Research now includes the effects of assembly aids such as the Personal Underwater Maneuvering Unit (PUMA), which is our simulator for the Man Maneuvering Unit (MMU), which will be used in space. Our results show that humans in space are far more productive at structural assembly tasks than previously expected, with a learning rate approximately twice as fast as is normal on earth construction projects. Parallel to this program on human productivity is a program initiated this year on Automation Robotic and Machine Intelligent Systems (ARAMIS), with advice from Professor Marvin Minsky of the Artificial Intelligence Laboratory. This work will lead to the definition of the optimum mix between human and automated activities in space. The Space Systems Laboratory is still involved in the planning of an experiment which will be carried into the low earth orbit by the Shuttle.

In addition to the zero-g research which is being simulated through the use of neutral buoyancy in water, there are two other activities which depend upon zero-g. This past year a group of students, under the direction of Assistant Professor Edward Crawley, has refined a facility which is called the Zero-G Structural Simulator (ZGSS). In this facility, structural specimens are launched into "free-fall" in a vacuum, and in this manner, material damping measurements can be made as a function of stress (or strain) level and of frequency. About one second of zero-g can be obtained. Another experiment is determining the effects of zero-g on flammability and ignition. In these experiments, zero-g is acquired by dropping the experiment package in a drop chamber at the Lewis Research Center of NASA.

Research has begun in the Flight Transportation Laboratory (FTL) under the direction of Assistant Professor Antonio Elias on an Air Traffic Control (ATC) simulator. The hardware, which has been loaned to the Laboratory, consists of a VAX 750, a Sanders Graphics display system with three displays for the ATC controllers, and three other terminals for the pseudo-pilots. The ATC simulator is one of three components for a new man-vehicle research simulation facility being constructed at the Ames Laboratory of NASA. Another new project in the FTL concerns aviation safety analysis. One of the tasks presently being undertaken is the design of a new accident investigation form to be used by the Federal Aviation Administration (FAA) and the National Transportation Safety Board.

Research directed toward the structural integrity of gas turbine engines is gathering momentum. Professor Theodore Pian is developing special assumed stress finite elements which can address the hot sections of the engine. Both Professors John Dugundji and Crawley are studying the structural dynamics of rotors. Professor Crawley is also conducting research on the behavior of advanced composite shafts for power transmission. Professor Lagace is being sponsored by Boeing Military Airplane Company to study the behavior of highly loaded structural components made of graphite-epoxy composite materials. Professor Witmer is studying the crash dynamics of advanced composite materials under a grant from the FAA.

The Gas Turbine and Plasma Dynamics Laboratory, under the leadership of Professor Covert, continues to attract wide support from both private industry and government. All of the major jet producers (General Electric, Pratt and Whitney, Rolls Royce, as well as Cummins Engine and Teledyne CAE) are among the sponsors. Associate Professor William Thompkins has assembled an array of minicomputers for the numerical solution of internal flows in jet engines. His present system has eight million floating point words of storage (larger than most commercial super computers), and can make four million point operations per second.

A cooperative program between the United States Air Force (USAF), industry, and academe known as AFRAPT (Air Force Research in Aircraft Propulsion Technology) was begun. Under this program, research in gas turbine structures and fluid mechanics will be conducted at MIT. Graduate students enrolled in this program will spend their academic year at MIT (or other university), and their summer working with one of the industrial sponsors.

Professor Shaoul Ezekiel's research on optical rotation sensors has gained international recognition. He has been conducting experiments to identify and quantify the fundamental limits of a passive resonator ring with an external laser and a pair of fiberoptic coils driven by a laser.

The Man-Vehicle Laboratory (MVL), under the leadership of Professor Laurence Young, is becoming increasingly involved with experiments which will be taken to a low earth orbit by the Shuttle. Negotiations are under way to fly the MVL experimental package on both the German-dedicated mission, and on Spacelab-4, the dedicated life science flight.

FACULTY

Appointments, Promotions, and Retirements

New appointments this year included: David L. Akin, as an assistant professor of Aeronautics and Astronautics, effective December 1981, whose interest is in space systems engineering; Paul A. Lagace, Charles Stark Draper Assistant Professor of Aeronautics and Astronautics, effective February 1982, whose interest is in advanced composite materials; and Bruce K. Walker, Charles Stark Draper Assistant Professor of Aeronautics and Astronautics, effective January 1982, whose interests are instrumentation, guidance and control.

Dr. Rudrapantna Ramnath accepted an appointment as an adjunct professor of Aeronautics and Astronautics effective July 1, 1981. He is an expert in aerospace vehicle stability and control, and taught two subjects this past year: 16.16 Introduction to Flight Vehicle Dynamics, and 16.17 Advanced Flight Dynamics and Control.

Walter M. Hollister, associate professor with tenure, will be promoted to professor of Aeronautics and Astronautics effective July 1, 1982.

We were fortunate to have Professor Saul S. Abarbanel, Rector of Tel Aviv University, as a visiting professor of Aeronautics and Astronautics for a second year. He worked in computational fluid mechanics.

Yehoshua Zeevi, a visiting associate professor of Aeronautics and Astronautics who is on sabbatical from the Technion, was also here for a second year. He participated in research on the application of eye movement measurement and analysis to scan patterns in pilots with Professor Young in the Man-Vehicle Laboratory.

We were pleased to welcome to the Department this year four visiting scholars from the Peoples Republic of China. Yu-Zhang Cao is working with Professor Alan Epstein in the field of turbine cooling. Si-Gong Chang is working with Professor Mar in the field of advanced composites. Guo-Cai Tang is working with Professor Edward Greitzer on flow distortions in gas turbine engines. Hong-Ming Wang is working with Professor Widnall on the use of lasers for flow measurements.

Christoph Wehrli, professor of the Eidgenossische Technische Hochschule in Zurich, spent part of his sabbatical in the Department as a visiting professor of Aeronautics and Astronautics. He worked with Professor Dugundji in the area of nonlinear vibrations and stability.

Robert Norton, an engineer at Rolls-Royce, began a two-year appointment as visiting engineer. He is participating in the Gas Turbine Laboratory's Rolls-Royce/ONR Blowdown Turbine Project, working with Professor Covert.

Four visiting engineers from the Peoples Republic of China who have been with the Department for the past two years have returned. They are: Da-Peng Chen, who worked with Professor Pian on finite element methods; Jun He, who worked in the field of optimal control of spacecraft with Professor Vander Velde; Zu-Wei Huang, who worked with Professor Miller in the Space Systems Laboratory; and Qi-Dong Yang who worked in the Innovation Center's 3D graphite display device project with Professor David Jansson.

Honors

Professor Covert was awarded the NASA Public Service Award in 1981 for his work with the Space Shuttle Main Engine.

Professor Young was selected as the 1982 Dryden Lecturer in Research of the American Institute of Aeronautics and Astronautics. He delivered the Dryden Lecture, "Human Orientation in Space" at the American Institute of Aeronautics and Astronautics (AIAA) Scientific Meeting in Orlando, Florida in January 1982.

Professor Trilling was elected a Fellow of the American Association for the Advancement of Science.

Assistant Professor Crawley received the Graduate Student Council Award for Teaching.

Professor Witmer received the 1982 Department of Aeronautics and Astronautics Teaching Award, presented by the students of the Department.

Special mention should be made of Monica M. Buellesbach, from Elm Grove, WI, a senior in the Department who was this year's winner of the Henry Ford II Scholarship, which is awarded to the engineering student with the best overall record.

Additionally, this year's winners of Department awards were as follows: the Luis De Florez Award, awarded to undergraduates who have demonstrated original thinking or ingenuity, to Lee D. Peterson, Class of 1982; Christopher M. Greiner, Class of 1983; Thomas D. Heimann, Class of 1982; Steven J. Isakowitz, Class of 1983; Gary A. Oliverio, Class of 1982; and Gary G.Vyhnalek, Class of 1983. The James Means Memorial Prize for excellence in Flight Vehicle Engineering went to Dale E. Gordon, Class of 1982; for excellence in Space Systems Engineering, to Christopher C. Johannesen, Class of 1982. The Henry Webb Salisbury Award, given in memory of Henry Webb Salisbury, Class of 1933, and awarded annually to a graduating senior in Course XVI for the highest degree of academic achievement, was awarded to Monica M. Buellesbach, Christos G. Kassapoglou, and Lee D. Peterson, all from the Class of 1982.

The Department student chapter of the AIAA were hosts to the 1982 Northeast regional AIAA student conference, held April 23 and 24.

JAMES W. MAR

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, and increased support for the Practice School and professorships. Large enrollment and vigorous research activity placed heavy demands on faculty time 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 in a flexible and concerned manner, maintaining its established standards of excellence.

Undergraduate Program

Undergraduate enrollment increased to 345 students, an all-time record, from the previous total of 319. 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:

	Undergraduate Enrollment				
	1976-77	1978-79	1979-80	1980-81	1981-82
Sophomores	107	98	107	99	127
Juniors	106	114	111	109	104
Seniors	99	106	117	111	111
Total*	312	318	335	319	342

*Does not include students in the five-year program who transferred to graduate school.

The faculty considered two areas of concern in the undergraduate curriculum in 1981-82. These areas involved the laboratory requirements for undergraduates, specifically the Department's lack of a unit operations course and lack of sufficient undergraduate labs necessary to fulfill departmental and Institute requirements for laboratory experience. Recommendations are being made by the faculty to improve these problems in the undergraduate curriculum as quickly as possible.

Graduate Program

Graduate enrollment rose to 230 full-time students, from the previous total of 207. Eighty-five students were enrolled in the doctoral program. Job offers for graduates at all levels continued to be attractive, but have seriously deteriorated since February when many major oil and chemical firms curtailed recruitment. The following table shows the trends in graduate enrollment:

	Graduate Enrollment				
	1977-78	1978-79	1979-80	1980-81	1981-82
Total Graduate Students	185	202	228	207	230
Doctoral Students	70	74	73	77	85

Forty-six graduate students were enrolled in the Practice School this year, an increase of 40 percent over last year. Students participated in project work at our Albany and Oak Ridge stations, and at a new station opened at the Bethlehem, PA mill of the Bethlehem Steel Corporation. The Albany station completed its fifth 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 31st 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 (SCEP) studies involve synthetic fuels research, nuclear fuel reprocessing, biochemical engineering, nuclear reactor safety, and controlled thermonuclear fusion. Projects at our Bethlehem station are coupled to ongoing process development and improvement work associated with steelmaking, coke formation, and by-product recovery. In addition, many projects deal with wastewater treatment and air pollution as well as energy conservation. Students usually attend two of the three stations during a single semester. The original program philosophy of an active internship has been maintained by exposing students to the practice of chemical engineering, utilizing group approaches to solving problems and developing communications skills.

Our new station directors for this year include Visiting Assistant Professor William Doerr (M. SCEP 1974, Sc.D. 1979), who operated the Oak Ridge Station during the fall semester and is presently directing the Bethlehem Station; Assistant Professor George Huff (Sc.D 1982), who is currently running the Oak Ridge Station; and Assistant Professor Montgomery Alger (S.B and M.SCEP 1978, Ph.D. University of Illinois), who directs the Albany Station.

The Friends of the Practice School committee, chaired by Dr. Jerry McAfee, (Sc.D. 1940) has completed the first phase of fundraising by securing a total of $240,000 per year from 24 companies to provide fellowship aid to Practice School students while they are taking classes in Cambridge. This 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, 1982, the sponsoring companies of the program include Air Products, Atlantic Richfield, Badger, Bechtel, Bethlehem Steel, Bonner and Moore, Dow Chemical, E.I. DuPont de Nemours, Ethyl Corporation, 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 and Webster, Sun Oil, Union Oil and Wheelabrator-Frye. The fellowship aid provided by the host and sponsoring companies is a major component in ensuring the continuation of this unique educational program at MIT. The Department appreciates this expression of support and confidence in the Practice School program.

New Developments

New faculty added to the Department in 1981-82 included: Associate Professor Ulrich Suter as the Texaco-Mangelsdorf Development Professor in polymer chemistry studies. Professor Suter was formerly a professor at the Swiss Institute of Technology. T. Alan Hatton, from the University of Wisconsin, was appointed an assistant professor, and has brought much-needed strength to the Department's transport and unit operations studies. From the University of Rochester, Howard Brenner was appointed the Willard H. Dow Professor, with research interests in fluid mechanics. A major addition to the faculty occurred with the transfer of Professors Daniel Wang and Charles Cooney to Chemical Engineering from the Department of Nutrition and Food Sciences. Their areas of specialty are fermentation and biotechnology. Within the Department, Professor John Longwell became the E.R. Gilliland Professor of Chemical Engineering, Professor Robert Reid was appointed the Chevron Professor of Chemical Engineering, and Professor Adel F. Sarofim became the Joseph R. Mares Professor of Chemical Engineering, succeeding Professor Kenneth A. Smith.

Another new development for the Department in 1981-82 was the establishment of a formally organized undergraduate office. Dr. C. Michael Mohr assumed responsibility for the direction of this new office, which will seek to organize more effectively the records, registration, and day-to-day administration of the Department's growing undergraduate population.

A new laboratory safety program was initiated, and Professor Michael Manning was appointed the Department's safety officer. Scheduled inspections of laboratory areas have been held and policy formulated to facilitate a more effective safety program.

Nationally and internationally distinguished scientists and scholars visited the Department this year. They included Professor John Davidson (University of Cambridge), Professor Lothar Riekert (Karlsruhe, Germany), Professor Joseph Merklin (University of Kansas), Assistant Professor Karsten Clement (Institutte for Kemiteknik, Danmark Tekniske Hojskole), Alan Michaels and Joseph Russell as adjunct professors, and David Goldstein and Joseph Boston as visiting lecturers.

Guest speakers for the Department's annual seminar series were: Professor Harmon Ray (University of Wisconsin), Dr. P.L.T. Brian (Air Products and Chemicals), Professor J.R.A. Pearson (Imperial College, London), Dr. Larry Thompson (Bell Labs), Professor Daniel Rosner (Yale University), Professor Carol Hall (Princeton University), Professor H.T. Davis (University of Minnesota), Professor Marcel Crochet (Universite Catholique de Louvain, Belgium), Professor Vladimir Hlavacek (SUNY at Buffalo), Professor James Davis (Institute for Paper Chemistry), Professor William Schowalter (Princeton University), Professor Richard Mah (Northwestern University), and Dr. M.L. Gorbaty. Dr. McAfee, president of Gulf Oil Corporation, was the third Warren K. Lewis Lecturer.

FACULTY

Professor James Wei, head of the Department, was appointed editor-in-chief of the journal *Advances in Chemical Engineering*. He continued to serve as an editor of the McGraw-Hill Book Series in Chemical Engineering, and on the editorial boards for *Industrial and Engineering Chemistry, Process Development and Design, International Chemical Engineering,* and *Chemical Engineering Communications*. He concluded an assignment as a member of the National Academy of Sciences Diesel Impact Study Committee, which this year published a report on the impact of diesel-powered light-duty vehicles. He served as a member of the Dean's Evaluation Committee for the Department of Chemical Engineering at the University of Michigan.

Professor Wei has remained active in professional societies. He is the vice chairman of the program committee, and session chairman for Synthetic Fuels for the joint meeting of the American Institute of Chemical Engineers (AIChE), and the Chinese Society of Chemical Technology at Peking to be held in September 1982. He is serving as chairman of the Seventh International Symposium on Chemical Reaction Engineering, to be held in Boston in October 1982. He is a member of the National Academy of Engineering's Peer Committee for Chemical and Petroleum Engineering. At MIT, he continues to serve on the steering committee for Whitaker College and as chairman of the Monsanto Grant Committee. He gave seminars on his research on catalysis and coal gasification at Northwestern University, the Catalysis Club of Chicago, and the gasification AIChE meeting at New Orleans.

Professor Robert C. Armstrong gave invited lectures at the Elastomers Gordon Conference in July, and at Cornell University in November. In addition, he presented papers at the Second World Congress of Chemical Engineering in Montreal, and at the AIChE annual meeting in New Orleans.

Professor Janos Beér served on the joint committee (board of directors) of the International Flame Research Foundation as the Foundation's Superintendent of Research, and also continued his membership on the Science Advisory Board of the Italian National Research Council. He joined an advisory committee under the chairmanship of Professor S.S. Penner (University of Southern California) to review the coal combustion research program of the Department of Energy (DOE). Professor Beér also gave invited lectures at the Combustion Institute's Italian Section meeting in Capri, and the Combustion Institute's meeting at Carnegie-Mellon University. He took part in an International Workshop on Soot Formation in Flames and its Toxicity, organized by NATO and the Université de Haute Alsace in Bischsenberg (France). Jointly with Professor Sarofim and Dr. L. Glicksman, Professor Beér gave a summer course on fluidized combustion at MIT.

Professor John F. Brady gave seminars on drop deformation and breakup in shear flow at the Université de Marseille and the Université de Nice. He presented a paper on rotating disk flows at the American Physical Society (APS) meeting in Monterey.

Professor Howard Brenner joined the faculty as the Willard H. Dow Professor of Chemical Engineering. He was elected a Fellow of the American Association for the Advancement of Science (AAAS). His professional activities included service as chairman of the session of polymer colloids at the 11th Northeast regional meeting of the American Chemical Society (ACS), and cochairman and organizer of the session of "Colloidal Phenomena -- State- of-the -Art" at the 74th annual meeting of the AIChE. Additionally, he serves as a member of the Scientific Committee of the upcoming Ninth US National Congress of Applied Mechanics, and is cochairing and co-organizing the session on tribology at that meeting, as well as serving as chairman and organizer of the session on low Reynolds number hydrodynamics at the upcoming Fourth International (Levich) Conference on Physiochemical Hydrodynamics. He continues to serve as associate editor of the *International Journal of Multiphase Flow,* topics editor of the *Journal of Physiochemical Hydrodynamics* and holds memberships on the selection committee of the Society for Natural Philosophy and the interfacial phenomena committee of AIChE. Seminars were presented by Professor Brenner at Clarkson College, Rutgers University, the Universities of Wisconsin, Rochester, Pennsylvannia, Missouri at Rolla, Missouri at Columbia, and Case Western Reserve. He also presented a paper at the ACS Las Vegas meeting.

Professor Robert A. Brown held the Joseph R. Mares Assistant Professorship in 1981-82. He presented invited lectures on the role of convection in melt crystal growth at Bell Laboratories, the annual meeting of the Society of Engineering Science, and the Ninth US National Congress on Theoretical and Applied Mechanics. Professor Brown also served on the program committees for and as session chairman for the Fifth American Conference on Crystal Growth (ACCG-V) and the Second International Colloquim for Drops and Bubbles.

Professor Robert E. Cohen has been on sabbatical leave since September 1981 and will be returning to MIT in June 1982. He has been doing applied polymer research in the area of semicrystalline polymers and copolymers for the Instituto Guido Donegani, the largest chemical company in Italy, located in Novara, Italy.

Professor Clark K. Colton continued as chairman of the Department's Graduate Admissions Committee. He served as a member of the executive committee of the American Society for Artificial Internal Organs (ASAIO) and as consultant to a committee of the Food and Drug Administration (FDA) concerned with hemodialysis standards. He continued to serve on the editorial board of the *Journal of Membrane Science* and as associate editor of the ASAIO Journal. He gave invited seminars at Carnegie-Mellon University and at the University of Minnesota.

Professor Cooney gave invited lectures at the International Conference on Computer-Aided Fermentation Processes, Manchester, England; Frontier of Biotechnology, Paris, France; Senior Executive Symposium, London, England; annual meeting, Federation of Financial Analysts, San Francisco, CA; and Engineering Foundation Separation Conference, Banff, Canada. He continued to serve as a member of the DOE Energy Research Advisory Board and is the vice chairman for the Biotechnology Commission of the International Union of Pure and Applied Chemistry (IUPAC). He has presented lectures and seminars at Union Carbide Corporation, A.E. Staley Manufacturing Company, Daniel Engineering, Cornell University, Purdue University, and the University of Delaware.

He has presented papers at the American Chemical Society, New York, NY; American Society for Microbiology, Atlanta, GA; and the AIChE/IEC meeting at Boulder, CO. Lastly, he is on the editorial boards of *Journal of Applied Chemistry and Biotechnology*, *International Biotechnology Advances*, and *CRC Handbook of Bio-Solar Resources*.

Professor William M. Deen received the American Society of Engineering Education Award (ASEE) for "excellence in the instruction of engineering students." He gave invited seminars on membrane transport phenomena at Harvard Medical School, Bell Laboratories, and Brown University (Division of Engineering), and was cochairman of a session on the pharmacokinetics of environmental toxicology at the AIChE meeting in New Orleans.

Dr. Wayne D. Erickson of the National Aeronautics and Space Administration was a visiting associate professor in 1981-82. He taught graduate courses in thermodynamics and combustion, and directed graduate student research on simulating the interaction of turbulent mixing and combustion.

Professor Larry Evans is currently taking a leave of absence to start his own company, ASPEN Technology.

Professor Hatton presented papers on liquid membrane operations; dispersion in groundwater aquifers; and dispersion, mass transfer, and chemical reaction in multi-phase contractors at meetings of the ACS (New York), the American Geophysical Union (Pingree Park), and the AIChE (New Orleans), respectively. He was invited to give a short course in Chicago, conducted under the auspices of the Center for Professional Advancement, on Mathematical Modeling in Mass Transfer and Fluid Mechanics.

Professor Jack B. Howard presented seminars to Sandia National Laboratory and at Pennsylvania State University, and participated in workshops and conferences in France and Germany. He served as program chairman of the 19th International Combustion Symposium to be held in August 1982 in Haifa, Israel. He served on the visiting committee of the Biomass Conversion Division of the Solar Energy Research Institute. Professor Howard continued as a member of the editorial board of *Combustion and Flame*, and he became a member of the international editorial board of *Fuel*.

Professor Longwell was appointed Executive Officer of the Department, replacing Professor Howard in that position. He continues to serve on the National Research Council's Energy Engineering Board, and the NASA Propulsion Advisory Board. An invited paper was presented to the NATO workshop held in France on Soot Combustion and Its Toxic Properties. Other invited papers were presented at the Detroit AIChE meeting, and at the MIT Industrial Liaison Program (ILP). Symposium on Synthetic Fuels.

Professor Manning gave an invited lecture at Tufts University summarizing his research in the area of CO oxidation on single crystal platinum catalysts. In addition he was cochairman and speaker at the joint symposium of the New England and New York Catalysis societies.

Professor Edward Merrill was an invited lecturer at Stanford University; California Institute of Technology; Battelle Memorial Institute, Columbus; IUPAC Macromolecules '81 at Strasbourg, France; and at a meeting of the ASAIO in Chicago.

Dr. Mohr, senior lecturer, received the Department's outstanding faculty award for excellence in teaching and research in 1982. He continued his work in the development of case problems in process design.

Professor Reid returned to MIT after spending the academic year 1980-81 at the University of Wisconsin as the Olah A. Hougen Visiting Professor of Chemical Engineering. In the fall of 1981 he was named as the first recipient of the Chevron Professorship in Chemical Engineering at MIT. While at Madison and during the current year, Professor Reid revised the graduate textbook, *Thermodynamics and Its Applications*. The book will be published by Prentice-Hall in the fall of 1982. As a continuation of his liquefied natural gas safety research, Professor Reid was chairperson of an international meeting dealing with this topic in March 1982. The symposium was co-hosted by MIT and the Gas Research Institute. The problem of explosive rapid-phase-transitions was a major topic, and the Alcoa Educational Foundation provided a grant for theoretical studies in this area.

Professor Sarofim was elected to the Board of Directors of the American Association of Aerosol Research. He served briefly on the Science Advisory Board of the Environmental Protection Agency (EPA), and is serving on the Committee on Hazardous Wastes from Laboratories for the National Research Council. He presented an invited plenary lecture, "Combustion-Generated Aerosols" at the First Annual Meeting of the American Association for Aerosol Research, presented invited papers on "The Chemical Composition of Combustion-Generated Aerosols" at the Workshop Conference on Heterogeneous Catalysis; and "Its Importance to Atmospheric Chemistry" and "Clean Coal Combustion - A Challenge for the 80's" at the Second World Congress of Chemical Engineering. He presented seminars on "Fluidized Bed Combustion: An Overview" in the MIT Mechanical Engineering Department and on "Aspects of Coal Combustion" at the University of California at Irvine. He also participated in courses on fluidized bed combustion presented at the MIT summer session and at ITP, Madrid. He was appointed to the board of the Journal, *Aerosol Science and Technology*.

Professor Charles N. Satterfield presented seminars or papers on Fischer-Tropsch synthesis at the Engler-Bunte Institute, Karlsruhe, West Germany; at British Petroleum, London; at an Industrial Liaison Program Symposium on Synthetic Fuels; at a DOE conference on synthetic fuels; and at the annual AIChE meeting. He was the keynote speaker, on trends in industrial heterogeneous catalysis, for an in-house symposium at American Cyanamid, and he lectured on catalytic hydrodenitrogenation at the Chevron Research Corporation, Richmond, CA. He accepted a second appointment, starting in 1982, as the chemical engineering member of the advisory board of the Advances in Chemistry Series of the ACS symposium series. For the Exxon Technical Education Program, he prepared special sets of lectures on mass transfer in coal processing, transport phenomena in CO/H_2 chemistry, and engineering considerations in reactor design and scale-up.

Professor Herbert Sawin held the DuPont Assistant Professorship of Chemical Engineering. He gave invited lectures at a Gordon Research Conference and the Digital Equipment Corporation. He developed a new course on integrated circuit processing for chemical engineers.

Professor Selim Senkan presented papers at the EPA's First State-of-the-Art Research Seminar in Environmental Engineering, and the AIChE annual meeting on the combustion characterisitics of chlorinated hydrocarbons.

Professor Smith, who has been associate provost of the Institute, assumed the additional duties of Vice President for Research. He is also the 1981 recipient of the Professional Progress Award, which is given annually by the AIChE; and he remains active in research in the Department.

Professor Suter joined the Department from the Swiss Federal Institute of Technology in 1981, and during his first year at MIT was invited to give lectures at Stanford University and the Scuola Normale Superiore in Pisa, Italy. He was nominated as a full member of Commission IV.1 (Polymer Nomenclature) of the IUPA. He was also named a visiting scholar at the IBM Research Laboratory in San Jose, CA.

Professor Jefferson Tester continued as the Class of 1942 Associate Professor and director of the School of Chemical Engineering Practice. He presented seminars on various aspects of geothermal reservoir engineering, including those given at the Reservoir Engineering Workshops held at Stanford University, Cornell University, and the Los Alamos National Laboratory. The Stanford Workshop paper presented an in-depth review of dispersion and mixing in fractured geothermal reservoirs. A paper on the operation of the School of Chemical Engineering Practice was also presented at ACS's "Learning for Life" symposium held in New York City.

Professor Costas Vayenas was on sabbatical leave during the 1981-82 academic year at Patras University in Patras, Greece.

Professor Preetinder S. Virk was invited to lecture at the University of Houston. He presented papers at the ACS national meetings in New York, and two more at the AIChE annual meeting in New Orleans. He also presented talks at Stone & Webster Engineering Corporation and the Eastman Kodak Research Laboratories.

Professor Wang served on the search committee for the new Dean of Science. He was awarded the Food, Pharmaceutical and Bioengineering award of the AIChE. He was an invited speaker at the Society of Industrial Microbiology, Reims, France; ASEAN, Fermentation Symposium,

Kuala Lumpur, Malaysia; and Biotechnology Conference, Costa Rica. He presented lectures and seminars at the Sloan School for senior executives, Combustion Engineering, Occidental Petroleum, Daniel Engineering, Ford Motor Corporation, National Bureau of Standards, Purdue University, Worcester Polytechnic Institute, and Carnegie-Mellon. He presented papers and chaired symposia at the American Chemical Society, NY; the Second World Congress of Chemical Engineering, Montreal, Canada; the Third Symposium on Biotechnology in Energy Production and Conservation, Gatlinburg, TN; and the AIChE, New Orleans. He continues to serve on the editorial boards of *Biotechnology and Bioengineering, Applied and Environmental Microbiology, Journal of Solid-Phase Biochemistry, and Applied Biochemistry and Bioengineering.*

Professor Glenn C. Williams continued to serve as Graduate Registration Officer for the Department, and on 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 is a member of the board of directors 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 Edward Ascoli. The American Institute of Chemists Award, offered to a senior in chemistry and/or chemical engineering who displays outstanding promise, was awarded to Laurence Philp. The AIChE annual scholarship award was given to junior John Cain. The Chevron Undergraduate Scholarships, presented for outstanding academic performance in the Department and for high professional promise as a chemical engineer, were awarded to William Merrill and Ivan Fong. The Chemical Engineering Special Service Awards, presented in appreciation of unselfish contributions to the success of Departmental activities, were given to graduate student Horacio Valeiras and undergraduate Nora Zirps. The Robert T. Haslam Cup was awarded this year to Gregory Dow in recognition of outstanding professional promise in chemical engineering. Patrick Bigot was the first recipient of the Rosemary J. Wojtowicz Memorial Prize, established this year to honor a Practice School student who exhibits exemplary performance in project work. Richard Blumenfeld won the first-place award at the New England regional AIChE student chapter conference held in April 1982. In terms of quantity and scope of professional and academic honors, the Department's graduating classes this year set a record for distinction and accomplishment.

RESEARCH

Combined interdisciplinary and departmental research for which Department faculty were responsible totaled approximately $5.4 million in 1981-82, compared to $6.2 million in 1980-81 and $5 million in 1979-80. The research volume generated by the Department alone was approximately $1.9 million, compared to $1.9 million in 1980-81 and $1.8 million in 1979-80. 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 has supervised research on fundamentals of non-Newtonian fluid mechanics and applications to polymer processing. In joint research with Professor Brown, new understanding has been developed as to the causes of difficulties in computing flows of highly elastic polymeric fluids. In other work, research on the rheology of particle-filled foams is leading to new methods for applying the ablator to the external tank of the space shuttle.

Research using the MIT-Combustion Research Facility has continued under the direction of Professor Beér. Experimental studies were carried out on the formation and oxidation of polycyclic aromatic hydrocarbons and soot in coal liquid flames, and on the combustion of coal-oil mixtures.

Professors Sarofim and Beér continued their contribution to the investigations of the combustion of pulverized coal, the pyrolysis and combustion of liquid fuel droplet arrays, and the modeling of fluidized combustion of coal.

Fluidized coal combustion experiments were carried out using the 500 KW pilot plant fluidized combuster to better understand the volatile evolution in the bed and the chemical reactions that occur in the freeboard of the fluidized combuster.

Professor Brady initiated a research program in suspension mechanics, which seeks to understand the dynamics of concentrated suspensions. A new approach is being used which allows the time evolution of the entire state of the system to be determined. Professor Brady also continued research into the relationship between similarity solutions of the Navier-Stokes equations and the real flows they are meant to represent, with particular application to the flow between two rotating disks.

Professor Brenner continued his research into generalized Taylor dispersion phenomena, extending the original analyses to include time-periodic systems. Transport processes in idealized (spatially-periodic) models of porous media continued to engage his attention, as did ongoing activities in the modeling of diffuse interfacial regions between immiscible bulk fluids. Contributing significantly to these theoretical endeavors were Drs. Pierre and Michèl Adler, visiting scientists on leave from the Centre National de la Recherche Scientifique (France).

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 direction solidification. Professor Brown also continued studies on the fundamentals of interfacial stability with work focusing on the fluid mechanics of composite drops. Another study, supervised in collaboration with Professor Armstrong, dealt with new methods for the numerical simulation of non-Newtonian flows.

In the area of biomedical and biochemical engineering, Professor Colton, in collaboration with Dr. Andrew Whitemore of the Brigham and Women's Hospital, 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 study was continued in collaboration with Dr. J. Stuart Seldner of the Joslin Research 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. A new study was initiated to investigate the mechanisms which control filtrate flux and hemolysis in membrane plasmapheresis for continuous separation of plasma from whole blood.

Professor Cooney continued research using alternative feedstocks in biological processes, with special emphasis on the use of C_1 compounds such as syngas and methanol. In the former area, the microbiological conversion of CO_2/H_2 to fatty acids is being examined. The use of methanol for the production of amino acids is being investigated. Professor Cooney also continues to study the microbiological utilization of lignocellulose, and the use of on-line computers for the monitoring and control of fermentation processes such as penicillin production. In collaboration with Professor Robert Langer of the Department of Nutrition and Food Science, studies of removal of heparin through enzymatic degradation have continued.

Professor Deen continued research dealing with transport processes in the kidney, hindered movement of polyelectrolytes through porous membranes, pharmacokinetics of nitrite and nitrate, and electrochemical processes for fabrication of microstructures.

Professor Hatton initiated studies on droplet dynamics in multiphase contactors to characterize and understand more completely the hydrodynamic and mass-transfer interactions in such devices. Work is continuing on the modeling of mass transport in liquid surfactant membrane systems. Some attention is now being given to understanding the breakage and swelling phenomena that can lower the extraction efficiency of liquid membrane operations. Research on the optimization of nutrient retention in the thermal processing of canned foods is now under way, and it is intended to extend this work to the mathematical modeling of industrial cookers.

Professor Howard continued research on coal pyrolysis and gasification. Effects of process conditions on product yields were studied, with a focus on mass transfer in molten coal particles and secondary reactions of primary coal pyrolysis products. He also continued studies on the formation and burnout of soot particles in flames and the roles of hydrocarbon flame intermediates in the emission of soot and polycyclic aromatic hydrocarbons.

Study of the reactions of aromatic over calcium oxide are being extended by Professors Longwell and Howard to include coal pyrolysis tars, since earlier work indicated a reduction in oxygen

content and in mutagenicity. Studies of soot and mutagen production in a specially designed jet-stirred combustor have shown that intense mixing during combustion can greatly reduce soot and polycyclic aromatic production. Joint investigations with Professors Longwell and Sarofim dealing with mathematical modeling of fluidized bed combustion of spent oil shale have indicated that calcium silicate formation can accelerate release of CO_2 from carbonates under typical operating conditions.

Also in collaboration with Professor Sarofim, Professor Longwell's studies of the factors determining the rate and extent of reaction of sulfur dioxide and oxygen with calcium oxide have shown that the most rapid reaction takes place on freshly decomposed calcium hydroxide, and that the extent of reaction continues to increase with increasing temperature. This is contrary to published literature which indicates a decreasing rate at high temperature. It is hoped that understanding and elimination of the factors that decrease reaction rate will increase the usefulness of limestone for sulfur capture.

Professor Manning continued research with Professor Reid in the area of reactor development for astronaut life support systems. His research group is also nearing completion of early experiments in new catalytic methods for oxidizing chlorocarbon chemicals, a major component of toxic waste inventories.

Professor Merrill continued previous studies on scission of macromolecules in dilute solution under conditions relevant to turbulent drag reduction, showing that the chains are fully extended and break into two nearly equal halves. X-ray photoelectron spectroscopy (XPS-ESCA) has been applied to polymer surfaces in which pendant groups (as in acrylate esters) can change their surface concentrations depending on local environment and method of deposition. Also under investigation is the surface modification of reinforcing fibers and fabrics for epoxy and other composites, in order to achieve covalent bonding. Remarkable improvement of strength has already been demonstrated in Kevlar®-epoxy composites. Polyether segmented polyurethanes continue under active study as biomaterials for medical applications.

Professor Reid's research interests are in several areas. Under National Science Foundation (NSF) sponsorship, he is continuing his studies in supercritical fluid extraction, with emphasis on the design of extractors as well as on the choice of an appropriate solvent fluid for various applications.

With partial support from the Nestle Company, Ciba-Geigy, and the Arthur D. Little Educational Foundation, the migration of chemical additives from polymer food wraps to food is being investigated.

A new group of studies on catalytic hydrodenitrogenation (HDN) has proceeded under the supervision of Professor Satterfield, utilizing a laboratory-scale trickle bed reactor. The HDN of quinoline, used as a model compound, proceeds very similarly in the liquid phase as in the vapor, although an inert liquid tends to equalize the adsorptivities of the various N-compounds formed as intermediates. The accelerating effect of H_2S on HDN reactions in general, found in our vapor-phase studies some years ago, occurs similarly in trickle-bed reactors. Some optimum partial pressures of H_2S, dependent on reaction conditions, have been determined.

Professor Satterfield's studies of liquid-phase slurry Fischer-Tropsch synthesis continued, focusing on reduced fused magnetite catalysts. The highly instrumented apparatus, centering on a mechanically stirred autoclave reactor, is proving to be an excellent means of determining intrinsic catalytic behavior in contrast to the more common use of vapor-phase reactors, many of which yield results of questionable value because of temperature gradients and various experimental artifacts. New information has been developed on product distribution and the effects of mass transfer on product selectivity. An associated program on the effect of solids on gas-liquid mass transfer has also been initiated.

Professor Swain has developed a research program, partially funded by a grant obtained from Digital Equipment Corporation, in reactive ion etching of silicon for integrated circuit processing. His studies center on the kinetic etching rate enhancements caused by ionic bombardment. 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 (CHC). In particular, the low combustion rates and high sooting tendencies of

chlorinated hydrocarbon flames were quantified. Studies on the chemistry and mechanism of chlorinated hydrocarbon flames were also pursued, and a new two-stage CHC combustion mechanism was developed. Research also continued in the area of low temperature, heterogeneously catalysed CHC combustion.

Professor Suter has established his research in polymeric studies. He is currently investigating the relationships between molecular structure and properties of polymers to predict polymer characteristics and control of polymer properties. He also is studying the synthesis of new polymers, their novel properties, and the conservation of fossil materials.

Professor Tester continued his studies of transport phenomena in fractured-porous rock reservoirs used for geothermal energy extraction. Work continued on the interpretation and numerical modeling of fluid dispersion as measured by tracer techniques. Both one- and two-dimensional models employing formation and velocity dependent dispersion coefficients were successfully developed to simulate field data from tests of a prototype hot dry rock geothermal reservoir located at Fenton Hill, NM. These efforts are coordinated with those of the staff of Los Alamos National Laboratory operating under US Department of Energy sponsorship. In addition to the tracer dispersion work, Professor Tester has continued studies of the dissolution and reprecipitation of minerals 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 was developed to interpret and predict geothermal reservoir performance. Work this year will focus on rates and mechanisms of deposition associated with cold fluid injection into the reservoir and on heat exchange surfaces.

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 of lignin thermolysis. He studied the mechanism of drag reduction by macromolecular solutions in turbulent pipe flow using collapsed and extended polyelectrolytes to discern equivalences among these additives. He collaborated with Professors Smith and Reid in experimental and theoretical research on the dynamics of LNG (liquified natural gas) storage tank response to atmospheric pressure fluctuations, to enhance the safety of above-ground LNG storage.

Professor Wang continued his research in the utilization of renewable resources for the production of chemicals. In particular, his efforts are directed toward the direct microbiological conversion of lignocellulose to ethanol. His other activities in this area include the use of immobilized whole cells for the microbiological production of acetic acid, acetone, and butanol. Professor Wang, in collaboration with Professor Evans, has extended activities in the design and construction of an automated filtration probe for maintaining filamentous fermentations. In addition, he has continued to study mass transfer enhancement in mycelical fermentations through cell attachment to porous beads. Lastly, Professor Wang continued his research on scale-up of microcarrier culture for mammalian cell propagation.

Professor Wei conducted research in the kinetics of catalytic hydrodemetallation of heavy oil, in the electrochemical catalytic oxidation of ethyl benzene and butane with Professor Vayenas, in the methanol conversion to olefins and aromatics over the zeolite ZSM-5, in coal gasification reactions and reactors, and in the optimal size of chemical plants under uncertainty.

Professor Sarofim conducted research in several combustion-related areas. First, studies of the production of aerosols by the vaporization and condensation of mineral matter in coal have provided major mechanistic insight on the production of submicron particles in combustors.

Char gasification rates are of importance in fuel-rich combustion and entrained flow gasifiers. A laminar flow furnace and auxiliary equipment for studying the reactions of CO_2 and H_2O with char have been constructed and tested. A complementary experiment is being set up to measure active sites on carbon surfaces in order to provide a better understanding of the variability of reactivities of chars. (With Professor Longwell).

The catalysis of carbon deposition on submicron inorganic particles produced by vaporization of mineral constituents provides a potential constraint on the operation of gasifiers and combustors. A flat flame burner with optical diagnostics for particle measurement has been constructed and is being used to study the deposition of carbon on aerosols of different composition starting with ferric oxide. (With Professor Longwell).

An experimental and theoretical study of using H_2/CO ratio as a diagnostic for mixing quality is under way. The usefulness of this technique for characterization of mixing quality in a laboratory well-stirred reactor is currently being studied, after which its application to problems of low Btu gas combustion will be assessed. (With Professor Longwell).

At the high temperatures involved in gasification and combustion processes most chemical reactions are too fast to be studied in currently available thermo-gravimetric analysis apparatus. An electrodynamic balance, in which a charged particle is suspended in an electrical field, has been adapted to high temperature applications by use of a CO_2 laser to rapidly heat the particles to reaction temperatures. (With Professor Longwell).

Studies on the temperature-histories of burning coal particles and impact on the formation of soot and nitric oxide are being continued. (With Professor Beér).

JAMES WEI

Department of Civil Engineering

During the past academic year the Department of Civil Engineering continued to develop its undergraduate and graduate educational programs and research programs. Building on its strengths in the areas of technology, systems analysis, and management, the Department is in a position to attack problems of major national and international importance in Civil Engineering and related areas. Major current and future Departmental directions include programs directed to the rebuilding of the decaying civil infrastructure in the US, natural resource development and utilization (including water and energy), development of our construction industry constituency, information systems as applied to Civil Engineering problems, and the relationship of management to engineering.

This report goes on to summarize major Departmental activities and faculty/staff honors and accomplishments during the past year.

UNDERGRADUATE EDUCATION

The 1981-82 academic year marked the second year of operation of the Department's restructured undergraduate program. This program was described in detail in last year's annual report. We continue to develop this program, particularly in the area of junior- and senior-level subjects and undergraduate laboratory subjects. For example, we strengthened our undergraduate laboratory subjects in environmental fluid mechanics and aquatic biology and chemistry, with increased emphasis on fieldwork by conducting water quality measurements in the Lower Mystic Lake.

The Department continues to be concerned about the level of undergraduate enrollment. In parallel with national trends, the Department's undergraduate enrollment has gone down since 1976; and although 1981-82 saw a relative stabilization, we are not satisfied with current enrollment.

In addition to the continued academic upgrading of our program, we have made a strong effort to raise the profile of Civil Engineering with the undergraduate population under the active leadership of Professor David Marks, undergraduate officer of the Department. In addition to those strategies discussed in last year's annual report, we have introduced Undergraduate Research Opportunity Program (UROP) traineeships, designed to introduce MIT undergraduates to exciting projects in the Department. Ten traineeships of $600 each were awarded to undergraduates working in research areas spanning the Department. The Chi Epsilon Chapter took responsibility for producing a first-rate Department newsletter (published four times during the year), which was distributed throughout the Department and to all freshmen at the Institute.

The Department continues its active participation in the Institute's Undergraduate Seminar Program offering five seminars, including: 1 S19 The River Nile: Its Use and Abuse (Professors Rafael Bras, Peter Eagleson, David Marks, and John Wilson), 1 S20 How to Live with Earthquakes (Professor John Biggs), 1 S21 The Microcomputer Revolution (Ms. Betsy Schumacker), 1 S22 What Happens If (When) the Gas Runs Out? (Professor Michael Meyer), and 1 S18 Opportunities in Civil Engineering (Professors Joseph Sussman and Ole Madsen).

Several new undergraduate subjects were developed during the past year. Among those are Microcomputer Project Laboratory by Ms. Schumacker; a substantially revamped subject, Analysis Methods in Water Resources and Environmental Engineering, coordinated by Dr. Eric Adams; a redesigned subject, Structural Mechanics, by Professor Victor Li; and a new subject, Applications of Mathematical Programming to Transportation Networks, by Professor Yossi Sheffi.

We see our undergraduate program as a priority area and will continue our efforts to upgrade it in order to attract first-rate students.

GRADUATE EDUCATION

The Department continues its broad graduate program in the three divisions of the Department (Water Resources and Environmental Engineering, Constructed Facilities, and Transportation Systems), as well as in a number of interdisciplinary programs around the Institute (as described last year).

In last year's report, we noted that graduate enrollment had grown from 202 in 1976-77 to 281 in 1980-81, and we felt that this program was somewhat too large for our existing faculty. To that end, strong steps were taken to limit the incoming class, and a reduction in overall graduate enrollment to 241, a more appropriate size, was achieved.

Several new graduate subjects were developed this year. These include Transit Management by Professor Nigel Wilson; Regional Transportation Program Development and Management by Professor Meyer and Thomas Humphrey; Computer-Aided Analysis in Geotechnical Engineering by Professor Amr Azzouz; a series of design subjects for bridges, buildings, and offshore structures by Professors Jerome Connor and Oral Buyukozturk; and Organic Compounds in Aquatic Environments by Professor Philip Gschwend. Major revisions to the subjects Risk Assessment in Engineering (Professor Erik Vanmarcke) and Water Resource Systems (Professor Bras) were also introduced.

RESEARCH

As in the past, the research program of the Department can be characterized as an integral component of our overall educational program, providing financial support and intellectual stimulation for undergraduate and graduate students, faculty, and staff.

The Department's research budget continues at a healthy level of $8 million a year (including research performed by Department faculty and staff through interdepartmental laboratories and centers). The research program of the Department is quite broad, encompassing work in technology, systems, and institutional analysis and management. Space does not permit a detailed description of our theoretical and experimental programs. Such descriptions are available, however, from Department headquarters for those who are interested.

Worthy of special mention is the Department's extensive involvement in research programs abroad. We have been particularly active in developing research opportunities dealing with important problems in the international community. Our faculty is currently involved in the following programs:

- Development of large-scale water resource and energy systems, urban transporation systems, and efficient highway construction materials in Egypt. This is in conjunction with the Technology Adaptation Program and Agency for International Development.

- A cooperative program in the area of innovative bridge design and construction conducted as a joint research and educational program with the Technical University of Berlin, West Germany.

- Research related to energy resources and extraction technologies in Venezuela -- sponsored by INTEVEP (Instituto Tecnológico Venezolana del Petróleo).

- Research related to planning and implementing large-scale transportation systems in Brazil -- sponsored by GEIPOT (Brazilian Agency for Transportation Planning).

- Research in rail operations, investment, and maintenance in Spain -- sponsored by RENFE (the National Railroad of Spain).

This international activity has had a significant broadening effect on the research perspectives in the Department and has doubtless had a positive effect on our program. At the same time, from a pragmatic viewpoint, the development of these research funds helps to buffer us against the vagaries of US Federal government research support. We feel that our international initiatives, together with those taken with the private sector in the US (particularly the construction industry), will provide more balanced research support than currently exists.

NEW INITIATIVES

Microcomputer Laboratory

In 1981-82 the Department established a Microcomputer Laboratory. The facility currently houses five microcomputers, including three HP-85 systems, one APPLE II+, and one IBM Personal Computer. It is intended as a hands-on facility, designed to further the academic and research programs of the Department. Centrally located on the second floor of Building 1, the Laboratory is convenient and accessible to faculty, staff, and students of the Department. A number of academic subjects made direct use of the facility for home problems and term projects, and many students used the facility to conduct research, often in the context of a graduate thesis.

The faculty feels that microcomputer technology will have a profound effect on research, education, and the practice of Civil Engineering. The Microcomputer Laboratory is an important mechanism for providing access to these devices for our faculty, students, and staff.

Center for Construction Research and Education

The Center for Construction Research and Education was established in the Department in 1981-82. The overall objective of the Center is to focus appropriate science, technology, and management methodologies on understanding and advancing the construction industry's vital role in socioeconomic development, and on improving the efficiency and effectiveness of the methods and resources used by the industry. This objective is to be pursued through a comprehensive program of basic and applied research, a graduate academic program, and a continuing education program. A multifaceted liaison program seeks to ensure close collaboration and involvement of construction industry personnel in the Center's research and educational activities.

Since its formal establishment in February 1982, and the appointment of Professor Fred Moavenzadeh as director and Charles Helliwell as deputy director, the Center has concentrated its efforts on defining a framework for its educational, research, and industry liaison programs and on initiating specific activities in several key areas. This framework includes a focus on three broad sets of issues: management (at the industry, firm, and project levels), resources (labor, materials, equipment, and finance), and technology (innovation, productivity, adaptation, and transfer). It also includes several theme areas of growing future importance to the industry such as the role of construction in energy conservation and resource development, technology and productivity, renewal and rehabilitation of infrastructure systems, management of super projects, computer applications for construction contractors, the role of the construction industry in socioeconomic growth and development, and international competition in the world market.

The Center's initial efforts in education are directed at expanding and strengthening the Department's existing advanced degree programs in Construction Engineering and Management, and at initiating

several continuing education courses and conferences for industry personnel. An educational subcommittee, chaired by Professor Marks, has been established to conduct a comprehensive review and assessment of the master's program in Construction Engineering and Management. This subcommittee is preparing recommendations for incorporating into the program several additional subjects which are currently offered by the various divisions of the Department.

In the area of continuing education, the Center is cosponsoring a conference for the chief executive officers of the top 125 construction firms from throughout the world. This conference, entitled "A Future Worth Building," is intended to stimulate an increased awareness of the potential role of the industry in creating a worthwhile future and to prepare an agenda for action which the industry might take to meet some of its more pressing challenges. The Center is also sponsoring two short courses. The first, Microcomputers in Civil Engineering, was presented in June and was designed to assist industry users and managers in making more effective use of microcomputers in both technical and management activities, and in reaching informed decisions for selecting software and hardware. The second, Rebuilding America: Meeting the Challenges of Reconstruction, is to be presented in October 1982, and is designed to identify changes in existing design and construction practices needed to meet the unique and increasingly complex requirements of the emerging multibillion dollar market in the renewal of private sector facilities and public infrastructure systems.

The Center has developed a number of research activities. Primary among these is a cooperative research program with the Spanish National Railroad (RENFE). The program is comprised of three distinct projects in support of a multibillion dollar capital program to expand, rehabilitate, and modernize the rail system, including: 1) operational service planning; 2) construction and rehabilitation program planning and project management; and 3) maintenance program planning and management. This research program provides a unique opportunity for the advancement of knowledge and understanding, and the development of new methodologies in the area of renewal and rehabilitation of infrastructure systems.

Other research projects include the development of quality standards and impact models for improved management of highway maintenance and rehabilitation programs; a feasibility study of establishing a practical size integrated process to quarry gypsum and manufacture gypsum-based construction products in Egypt; and, under a grant from the MIT Energy Laboratory, the preparation of an agenda and priority of research topics on the role of construction in meeting future energy-related construction demands.

Several activities directed at establishing liaison with the construction industry are currently under way at the Center. A series of meetings with local industry firms is ongoing, and an industry affiliates program is under consideration. Such a program would provide the structure for effective ongoing relationships between the Center and industry firms, and among the member firms themselves. It is envisioned that participation in the program will be opened to all who share an interest in the future of construction and who play a role in the construction process.

FACULTY AND STAFF

The following faculty members were promoted during this past year: Dr. Nigel Wilson and Dr. Herbert Einstein were promoted to full professor, Drs. Sallie Chisholm, Gregory Baecher, and Rafael Bras to tenured associate professor, and Drs. Harry Hemond, Michael Fardis, and Michael Meyer to associate professor.

Professor Biggs retired from the Civil Engineering faculty after 35 years of service. Professor Biggs specialized in structural engineering and design, and contributed with distinction to the Department and the structural engineering community during his career. A colloquim entitled "Structural Engineering: Research, Education, and Practice" will be held at MIT in September 1982, in his honor on the occasion of his retirement.

The Department accepted the resignation of the following faculty members: Dr. Hilary Max Irvine, associate professor; Dr. Roman Krzystofowicz, assistant professor; Dr. David Ashley, associate professor; Dr. John Wilson, associate professor; and Dr. Paul Roberts, professor. The former three have accepted academic positions, and the latter two will pursue professional practice in their specialties.

Five members of the faculty were on sabbatical leave. Professor C. Allin Cornell spent the year at Stanford, conducting research and participating in teaching. Professor Moshe Ben-Akiva spent the year in Israel, in residence at the Technion, conducting research. Professor Einstein spent the year in Europe, participating in various research programs, particularly at ETH (Eidgenoessische Technische Hochschule) in Zurich, Switzerland, and in Norway. Professor Chiang Mei traveled abroad and worked in Cambridge on new research initiatives. Professor Daniele Veneziano spent the spring semester in Europe, working on new research directions.

Several faculty searches were conducted during this academic year. As a result, three new faculty members will join the Department beginning with the 1982-83 academic year. Dr. Lynn W. Gelhar will join our faculty as a professor of Civil Engineering, specializing in the area of groundwater hydrology and quality. Dr. John Slater will join the Constructed Facilities Division, and Dr. George Kocur will join the Transportation Systems Division, both as assistant professors of Civil Engineering. We continue to seek exceptional faculty in several areas, in order to strengthen our Departmental programs.

The faculty of the Department continued a substantial degree of involvement in professional societies and related activities, maintaining active membership in more than 50 professional organizations. Notable among the honors and recognition achieved by our faculty are the following:

Professor Eagleson was elected to the National Academy of Engineering. He joins Professors Robert Whitman, Donald Harleman, T. William Lambe, and Cornell, colleagues in the Department who have been previously so honored.

Professor Harleman gave an invited lecture at the celebration seminar for the 150th anniversary of the University of Hanover, West Germany, in July 1981, entitled "Hydrothermal Problems in Water Bodies."

In October 1981, at the American Society of Civil Engineers annual convention, Professor Whitman gave the Terzaghi Lecture on the subject of "Evaluating Calculated Risks" in geotechnical engineering. This is one of the most prestigious honors in the geotechnical field.

Professor Bras received extraordinary recognition during this past year. He received the Horton Prize and the James B. Macelwane Award from the American Geophysical Union in recognition of his significant contributions in hydrology and geophysical sciences. Also, he received a John S. Guggenheim Fellowship for the 1982-83 academic year, during which he will be on sabbatical leave.

Dr. Ann Friedlaender, professor of Civil Engineering and Economics was named Head of the Department of Economics at MIT, effective January 1983.

Dr. Lambe, Edmund K. Turner Professor of Civil Engineering, Emeritus, was named the 1982 Distinguished Engineering Alumnus of North Carolina State University.

Professor Nigel Wilson was the recipient of the Department's award for Conspicuously Effective Teaching.

Jamil Nasir, a junior in Civil Engineering, was the first recipient of the Dean A. Horn Undergraduate Research Award for work done in offshore structural monitoring and conducted with Sea Grant/ UROP support.

Dr. Robert J. Olsen, a postdoctoral associate in the Department, won the 1981 Eckart Dissertation Prize of the Scripps Institution of Oceanography for the most original and stimulating dissertation. Dr. Olsen's work is concerned with nitrogeneous nutrients in the ocean.

Ms. Sandra Hull was named the first recipient of the Department's Exxon Teaching Fellowship.

The Department was pleased to have the following as visiting faculty during the past year: Professor Avishai Ceder (Technion, Israel Institute of Technology), Professor Themistocles Dracos (Swiss Federal Institute of Technology), Professor Hugo Perez La-Salvia (Catholic University, Venezuela), Professor Masaki Sawamoto (Tokyo Institute of Technology), and Professor Cornelius Sullivan (University of Southern California).

VISITING COMMITTEE ACTIVITIES

Dr. Harl Aldrich will become chairman of the Visiting Committee, effective July 1, 1982, and the Department is looking forward to working with him. Dr. Aldrich replaced Harold Muckley who for the past several years guided the Committee and served the Department with great distinction. We are most appreciative that he will continue to serve as a member of the Committee.

The next Visiting Committee meeting is planned for December 1 and 2, 1982. The Department Head met with Dr. Aldrich on several occasions to discuss current Department issues and to plan this upcoming meeting.

Completing their terms on June 30, 1982, are Richard A. Carpenter, Dr. R.E. Fadum, and Dr. Joseph Penzien. We wish to thank these members for their guidance during their terms on the Committee.

The Department welcomes the following as new members of the Committee, all effective July 1, 1981: Professor Steven J. Fenves, Carnegie-Mellon University; Barbara M. Johnston, George Hyman Construction; Charles N. Olsen, Union Pacific Foundation; E. Alfred Picardi, Oxford Properties, Inc.; and Major General Hugh G. Robinson, US Army Engineer Division, Southwestern.

SEMINARS AND PROGRAMS

The Department's faculty participated in a variety of seminars and other programs during the past year. Notable among these are the following: The Superprojects -- During the Independent Activities Period (IAP), the Department offered a series of four seminars dealing with the challenges of designing and implementing very large-scale Civil Engineering projects. Topics included "The Challenges of Commercialization of Shale Oil" in the US, "The Qattara Depression Hydroelectric Project" in Egypt, "The Interstate Highway System" in the US, and "The Dead-Med Canal" in Israel. The series was well attended by faculty and students from throughout MIT, as well as by people from the local professional community.

Past, Present, and Future of Geotechnical Engineering -- In September 1981, to honor Professor Lambe on the occasion of his retirement from the faculty, the Department sponsored an international symposium on geotechnical engineering. More than 100 distinguished educators, practitioners, and researchers from throughout the world attended this meeting.

Professors Harleman, Keith Stolzenbach, and Dr. Adams conducted a subject on Engineering Aspects of Waste Heat Disposal in the Water Environment at the National Civil Engineering Laboratory in Lisbon, Portugal, in July 1981.

Professors Steven Lerman, Marvin Manheim, and Ben-Akiva conducted a subject in cooperation with MIT's Industrial Liaison Program and the Center for Transportation Studies on Transportation Systems Analysis and Planning, sponsored by the Association for Planning and Transportation Studies in Japan.

The Department hosted the visit to MIT of Dr. Raphael Caldera, former president of Venezuela. Dr. Caldera gave a very well attended seminar entitled "Education and Development Needs of Latin America."

The Department sponsored a symposium on "Highway Bridge Maintenance and Rehabilitation" held at MIT in April 1982. The symposium focused on the areas of bridge maintenance and evaluation of current structural conditions, rehabilitation and repair technologies, and operation during construction and repair. More than 100 bridge engineers attended from the New England States and New York.

JOSEPH M. SUSSMAN

Department of Electrical Engineering and Computer Science

An academic year has passed since the Department's new administration was installed. With Joel Moses moving from Associate Head for Computer Science to Head of the Department, Richard Adler remaining as Associate Head for Electrical Science and Engineering, and Peter Elias assuming responsibility as Acting Associate Head for Computer Science (having served as Department Head from 1960 to 1966), the keynote has been continuity, especially with the initiatives and aspirations developed during the short duration of the previous administration (1978 to 1981). We have been spared much of the transient burden normally expected when both a Dean and a Department administration change at the same time, because Dean Gerald Wilson was already thoroughly familiar with the Department's organization and procedures.

Construction of the new EG & G Education Center (Edgerton, Germeshausen & Grier) is well under way, although somewhat delayed from the original schedule. It is now planned for occupancy in Spring 1983, rather than in time for the Department's centennial celebration on October 2 and 3 1982.

The theme for the centennial is "Lifelong Cooperative Engineering Education," a new concept in which industry and universities cooperate to mix education and professional work during the whole career of the engineer. Two preliminary workshops with representatives from industry and academia were held during the year, in preparation for the final symposium on October 2.

Although it is now clear that the whole book by Professor, Emeritus, Karl L. Wilder and Nilo Lindgren, "A Century of Electrical Engineering at MIT," is not likely to be ready for the centennial celebration, some illustrative samples from it will be on exhibit.

Plans for the textbook series on the undergraduate "core" curriculum have been advanced greatly by the conclusion of an agreement between the MIT Press and McGraw-Hill, in which the Press will publish and distribute internationally while McGraw-Hill will distribute elsewhere. Publishing through this medium is entirely optional for the authors, and it is hoped that several will find the arrangements attractive.

We are pleased that a gift from Digital Equipment Corporation of a VAX 11/750 has allowed us to make the first-needed expansion of the Department's educational computer facility, now more than two years old.

Our new research facilities for the VLSI-related Microsystems Program are in the intensive design stage, with occupancy expected in spring 1984.

The robotics program has gone through its "year of the robot" phase under the auspices of the AI (Artificial Intelligence) Laboratory, and detailed plans for research and educational material have been formulated. New space and personnel for the program are within view and there is considerable interest in supporting the work. We expect that both the robotics and the VLSI-related programs will serve as major forces to draw together the "EE" and "CS" components of the Department.

During this year, the directorship of the Laboratory for Information and Decision Systems (LIDS) passed to Professor Sanjoy K. Mitter, and that of the Research Laboratory of Electronics (RLE) to Professor Jonathan Allen. The Department looks forward to continued close and successful relationships with these laboratories, and to working with Professors Mitter and Allen in their new roles.

UNDERGRADUATE PROGRAM

Enrollment of undergraduates averaged 1,070 in 1981-82, with about 65 percent in the Electrical Engineering program and 35 percent in the Computer Science program. The total represents an increase of about 20 students from the previous year.

The offering of the fourth and final subject in the undergraduate core sequence, 6.004 Computation Structures, is awaiting the completion of the new EG&G building, which will provide the needed laboratory space.

There were no new undergraduate subjects offered in the Department this year. Several of our existing ones were restructured, however, to reflect new emphases. Among these were 6.114 Real-Time Computing and Control Laboratory, and 6.115 Microcomputer Project Laboratory.

The following prizes and awards were won by our students. The Ernst A. Guillemin Prizes for outstanding S.B. theses in the Department were awarded to Jonathan S. Abel of Sarasota, FL (first prize), Philip A. von Guggenberg of Alexandria, VA (second prize), and Richard M. Soley of Camden, ME (third prize). The Computer Systems Prize for the outstanding thesis in Computer Systems was awarded to Clifford V. Ludwig of Media, PA. The William A. Martin Memorial Prize was won by James R. McLaughlin of St. Louis, MO. This is a new award in honor of Professor William Martin, who died last year, for the best undergraduate thesis in Computer Science. The Honeywell Award for outstanding achievement in Engineering was won by Wesley G. Bush of Winnetka, IL. Special Departmental Awards for Meritorious Service were given to Stu-Fac Committee-Crosstalk editors J. Frank Camacho of Los Angeles, CA; Michael A. Isnardi of Fort Lee, NJ; and Richard M. Soley of Camden, ME; as well as to the president of Eta Kappa Nu, John C. Gonzalez of Flemington, NJ.

The following special scholarships were awarded to our students: the Digital Equipment Corporation Scholarship in support of an outstanding woman undergraduate in Engineering was won by Deborah J. Pekala of Greenville, PA; General Motors Scholarships for academic excellence were awarded to Duane S. Boning of Sunnyvale, CA, and to Stephen K. Dixon of Columbus, IN; and an Eastman Kodak Scholarship for academic excellence was awarded to Ken E. Miyano of Northbrook.

GRADUATE PROGRAM

In September 1981, there were 548 graduate students enrolled in the Department. Of this number, 186 were newly admitted students. About 20 percent of the total were foreign nationals. The Department supported 215 research assistants, 108 teaching assistants, and awarded 18 fellowships. In addition, there were 11 National Science Foundation Fellows and 19 Hertz Fellows. The remaining students had industrial or foreign government support or were using their own funds.

During 1981, the Department awarded the following graduate degrees: 161 masters of science, 28 electrical engineers, and 47 doctors of philosophy.

The Department received 1,565 applications for the 1982-83 year, the largest number we have ever had. The applicants were generally excellent and 297 were admitted, of whom we expect 205 to register for next fall.

Graduate students Martin F. Schlecht, Davis Y. Pan, and Daniel J. Van Hook were given Supervised Investors Services, Inc. Awards for outstanding teaching performance by graduate students in the Department. The Carlton E. Tucker Award for Excellence in Teaching was won by Tarek M. Habashy, and the new Harold L. Hazen Award, funded by an anonymous donor, was won by Susan A. Hall. Both awards carried the same citation. In recognition of his excellent performance as a teaching assistant, Ronald D. Williams was promoted to Instructor-G.

The Exxon Teaching Fellowship, a special three-year award to encourage and support a doctoral student in engineering with interests in teaching, was awarded to Andrew W. Yagle, for his outstanding teaching contribution to the Department.

VI-A PROGRAM

The spring of 1982 saw 178 Course VI students apply for admission to the VI-A Program. Although down from the previous year's all-time record of 195 applicants, the 178 represented a 1 percent

increase from a 9 percent smaller Course VI sophomore class. The participating companies conducted 916 interviews among these applicants during the two days in March that they were on campus, which led to the final selection of 91 to enter in June 1982 as the new VI-A class. This represented an acceptance rate of about 51 percent of those applying -- up about 3 percent over last year.

The downturn in the US economy didn't manifest itself in a lowered demand for VI-A students. The companies came up with 102 openings, comparable to the past several years.

This is the second year of the Department's imposed ceiling of approximately 85 for an entering VI-A class. This is the mechanism for bringing VI-A's total enrollment down to a manageable level of 250 juniors, seniors, and graduate students.

Arrangements which had started several years ago were completed with VI-A alumnus Raymond S. Stata, Class of 1957, and president of Analog Devices. The company joined VI-A in time to recruit their first two students this spring. Professor Rafael Reif was appointed Analog's first VI-A faculty advisor.

Of those 68 VI-As admitted to graduate school in June 1982, five received early admission, 22 regular admission, and 41 (60 percent) received the special "SM-only" restricted admission. Thus 69 percent of this year's VI-A seniors were admitted to the graduate phase of the Program -- pretty much a steady-state figure for the past few years.

VI-A was 65 years old in 1982, having taken its first students in 1917 and remaining in continuous operation since. It, and Stanford University's Honors Co-op Program, have been endorsed at the Department's two centennial workshops on "Lifelong Cooperative Education" as prime examples of how academia and industry can collaborate in engineering education.

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 (James R. Melcher)

Projects in this Laboratory generally combine basic and practical goals and often are concerned with interactions between electromagnetic fields and ponderable media.

Three of the projects carried out by Professor Melcher and his students have practical objectives:

1) In support of the industrial development of magnetically stabilized beds, approaches have been identified that have practical promise for transporting liquid-entrained magnetizable particles. These use the change of state of the particle system, as it is mediated by the application of a magnetic field, to promote the pneumatic transport of the particles. The rheology of continua formed from fluid-permeated magnetizable particles solidified by a magnetic field has been studied, with emphasis given to pneumatically induced plastic deformation and fracture.

2) A project has been completed on the behavior of spouted beds under electric stress. With the objective of creating a new class of fine-particle gas filters, investigations centered on bed mechanics and filtration efficiency with the spout subjected to a corona discharge.

3) Investigation of electrofluidized beds in the control of diesel exhaust led to studies of oils that were found to reduce greatly the electrical losses that typically limit the application of such devices to the control of carbonaceous materials.

Professor Alan J. Grodzinsky and his students continue to study the electrochemical and physicochemical properties of connective tissues. 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 and the accompanying changes in the cartilage's mechanical and biochemical properties (characterized at Children's Hospital). Enzymatic degradation *in situ* is now being explored in order to elucidate the nature of the breakdown of the charged molecules. 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 collagen and synthetic gel membranes may alter intermolecular spacing and hence alter solute permeability.

Professor Jeffrey H. Lang, in collaboration with Professor David H. Staelin, their students, and the RLE, is 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. Closed-Loop reflector figure control is necessitated by the flexibility of the membrane. Advanced control theories have been developed and demonstrated on preliminary experiments. A five-foot reflector has been constructed, and the required control theories are being applied to control this reflector actively. Concurrently, Professor Lang, his students, and EPSEL, are involved in the design of variable-reluctance-motor-base propulsion systems for electric vehicles. Motor and electronics models and simulations have been developed in order to facilitate the optimized design of the propulsion system. Finally, Professor Lang and his students are also developing special-purpose microelectronics and new control algorithms intended to advance the state of digital control system implementations.

High Voltage Research Laboratory (Professor Melcher)

During the past year activities at the High Voltage Research Laboratory have expanded into the areas of electrical insulation and uses of radiation, both central topics of interest. These new studies all basically involve more advanced diagnostics, which are used to develop better models for insulation behavior under high electric stress and for analysis of radiation effects. This work includes electro-optic Kerr effect studies in liquids, partial discharge pulse-height analysis of solid insulation defects, electron ejection to probe space-charge effects, the influence of high magnetic fields on electrical treeing, and computerized tomography for defect detection. These projects are well coordinated with and support the more applied projects, such as the program on the reliability of compressed-gas insulation for electric power transmission apparatus. Close links to more general issues of electrodynamics are maintained by liaison with the Continuum Electromechanics Group, and by projects involving electrohydrodynamic instabilities, fluidized beds, and static charging of fluids.

Stroboscopic Light Laboratory (Professor Harold E. Edgerton)

The development of a compact, ultra-sensitive underwater television camera system, which will be capable of operation from small boats, continues on a low-key priority. The elimination of auxiliary incandescent lighting should provide improved image quality and seeing distance, with drastically reduced power requirements. This work is supported by the National Geographic Society.

Underwater marine life is being photographed, with a high-speed motion picture camera, for inclusion in a proposed high-speed movie. Improved electronic flash systems have been developed and used where exposures of less than 0.1 microseconds are required.

Hardware and software systems are being developed in conjunction with the MIT Spectroscopy Laboratory (Professor Michael Feld) to perform time-resolved spectroscopy of pulsed light sources in the visible through near infra-red spectral range.

Research also continued on the acoustic measurement of height and vertical velocity of aircraft.

Numerous visitors from the Institute, the US, and overseas continued to come to the Strobe Lab for advice.

FACULTY

Faculty promotions this year included Dimitri P. Bertsekas, Clifton G. Fonstad, William A. Martin (deceased), and Patrick H. Winston to full professor; and Arvind, Pierre A. Humblet, and Jae S. Lim to associate professor.

H. Kent Bowen, professor of ceramic engineering and electrical engineering, was named Ford Professor of Engineering in the School of Engineering. Alvin W. Drake was appointed Cecil H. Green Professor of Electrical Engineering for one year; and Jack B. Dennis, Professor of Computer Science and Engineering, was appointed a Vinton Hayes Fellow for the same period.

Joining our faculty this year were Dr. David J. Edell, jointly appointed as an assistant professor of Electrical and Bioengineering with the Division of Health Sciences and Technology and this Department; Dr. Tomas Lozano-Perez, formerly a research scientist with the Artificial Intelligence Laboratory, is now an assistant professor of Computer Science and Engineering; Dr. Terry P. Orlando, who received his Ph.D. from Stanford University, is now an assistant professor of Electrical Engineering; and Dr. Maurice V. Wilkes, professor, emeritus of Computer Technology at the University of Cambridge, England, and now with Digital Equipment Corporation, was named an adjunct professor of Computer Science and Engineering.

Dr. Fernando J. Corbato, professor of Computer Science and Engineering, and director of Computing and Telecommunication Resources, was the charter recipient of the Computer Pioneer Award, established by the Institute of Electrical and Electronics Engineers (IEEE) Computer Society to recognize contributions made at least 15 years ago to the concepts and development of the computer. Dr. Corbato was recognized as a pioneer in the development of multiple-access computer systems. Dr. Mildred S. Dresselhaus, Abby Rockefeller Mauzé Professor of Electrical Engineering and Physics, and director of the Center for Materials Science and Engineering, was elected vice president of the American Physical Society. In addition, Professor Dresselhaus received an honorary Sc.D. at Hunter College's 150th commencement exercises in June for promoting the role of women in science through example and active concern. She also has been designated by the American Carbon Society to deliver their Graffin Lectures, a series to be presented in this country and abroad during the coming year. Dr. Hermann A. Haus, Elihu Thomson Professor of Electrical Engineering, was selected as the receipient of the James R. Killian, Jr. Faculty Achievement Award, which recognizes extraordinary accomplishments by MIT faculty members. Dr. James H. McClellan, assistant professor of Electrical Engineering, received an award from the Graduate Student Council for outstanding teaching in a graduate subject. Dr. Melcher, Julius A. Stratton Professor of Electrical Engineering and Physics, and director of the High Voltage Laboratory, was elected to the National Academy of Engineering.

The Department was happy to welcome several visiting faculty during the academic year. During the fall term Visiting Professor Norman Abramson continued his sabbatical from the University of Hawaii, conducting research on satellite communications. Visiting Professor Gunnar Fant, on sabbatical leave from the Royal Institute of Technology of Sweden (KTH), taught a seminar and conducted research in speech communication. Visiting Associate Professor Nancy A. Lynch, on sabbatical for the year from the Georgia Institute of Technology, conducted research in distributed networks and taught subjects in the Department's computer science program. Visiting Associate Professor Charles Van Loan, while on sabbatical leave for the fall term from Cornell University, taught a subject on matrix computations in numerical linear algebra.

Department faculty who were away during the year included: Associate Professor Carl E. Hewitt, on leave of absence for the fall term, working in VLSI at Texas Instruments; Associate Professor Berthold K. Horn, on sabbatical leave for the fall term at the University of Witwatersrand in South Africa and writing a book on computer-controlled manipulators; Professor Robert S. Kennedy, on leave of absence in the spring term conducting research at Lincoln Laboratory on air traffic control; Professor Jin A. Kong, on sabbatical for the fall term completing a textbook on electromagnetism and visiting universities and research institutes in the Far East; Associate Professor Christos H. Papadimitriou, who began a two-year leave of absence in the spring term to serve as visiting professor at the National Technical University of Greece in Athens; Associate Professor Vaughan R. Pratt, on leave of absence to serve as visiting professor at Stanford University; and Associate Professor Ronald L. Rivest, on sabbatical leave in the spring term, developing a textbook on cryptography.

Resignations from the Department's faculty included Assistant Professor McClellan, Associate Professor Pratt and Adjunct Professor Stanley R. Rich.

Professor Wilbur B. Davenport retired from the Department, to take up residence in Hawaii and accept a part-time faculty position at the University there.

JOEL MOSES

Department of Materials Science and Engineering

During the past academic year the expansion of the Department has continued. The number of undergraduates increased by 13 percent, graduate students by 14 percent, and research support by more than 12 percent compared with the previous year. Thus, a four-year trend showed no signs of abating and our already overextended resources were further strained. The shortage of space became acute. We planned a major rearrangement of space utilization within the space available to the Department. It is hoped that all of the moves and renovations proposed in the plan will be completed before the end of the summer. One benefit which should result is that, for the first time, all of our faculty working in polymer science will be together in Building 13 and will thus be able to make better use of common experimental facilities. We were pleased to learn that a little more space will be available to us next term, which should help to relieve some of the overcrowding in the Corrosion and Materials Processing laboratories.

Undergraduate Program

There were 144 undergraduate students registered in Courses III, IIIA, and IIIB, 40 percent of whom were women. Seventy-nine of these students, nearly half our undergraduate population, elected Course IIIB, the Department's co-operative work-study program. These students were placed in 28 different companies representing a broad cross section of industry. Professor Thomas B. King and Joseph M. Dhosi continued as principal advisors and organizers of this very successful program. Interest among industrial companies continues at a high level.

The undergraduate curriculum, which is designed to give students a sound understanding of basic materials science and engineering with an introduction to a limited number of more specialized subjects, was unchanged from previous years. It appears to serve most of our students well, the majority of whom continue on to more specialized studies in the field at the graduate level.

The enrollment in 3.091 Introduction to Solid-State Chemistry approached 500 students as in the immediately preceding years. This subject was taught and supervised by Professor August F. Witt in the fall term and Professor Robert M. Rose in the spring, with the able assistance of a group of devoted faculty members and teaching assistants. The popularity of the required laboratory subject 3.081 also continued. More than 100 students, including a substantial number from other departments, obtained hands-on laboratory experience in a variety of metallographic, X-ray diffraction, and electron optical techniques in this subject, which has been run so successfully by Professor Robert E. Ogilvie for a number of years. In response to student demand, this laboratory was offered both terms. The maintenance and modernization of equipment in the undergraduate laboratories has been a major problem in recent years. Three years ago we started a planned renovation of all the equipment. Last year we were able to effect a major improvement, and we have every expectation that in a year or two from now the laboratories will be in good shape.

Graduate Program

There were 233 students registered in Departmental graduate programs, which is an all-time high. Sixty-two percent of these students were supported by research assistantships and 52 students held fellowships, many of them provided by industry. More than 70 percent of the graduate students were US citizens. The remainder were students who came from many different countries.

Compared with the situation in the undergraduate program, a smaller proportion of the graduate students were women. However, the 40 women graduate students enrolled in 1981-82 represent a continuing, but slow, increase in the number of women in the Department's graduate programs.

Eighty-four graduate degrees (32 doctorates, 52 masters) were awarded to students in the Department of Materials Science and Engineering at Commencement ceremonies in June 1982. The numbers were for the most part uniformly distributed between the five graduate programs: Ceramics, Materials Engineering, Materials Science, Metallurgy, and Polymer.

Research

Expenditures on research also reached an all-time high in 1981-82, the rate of increase being considerably in excess of the inflation experienced in that period. To help our faculty meet their many research commitments and to help with the supervision of the research and graduate students, we have increased the number of research associates and other postdoctoral people in recent years. We now have two senior and two principal research scientists working in the Department, and we hope to add at least one more person in each category in the near future.

The whole field of materials processing has experienced the most rapid expansion of all the research areas in the last two years, and this is reflected in the very healthy growth of the Materials Processing Center. Within this field, major emphasis continues on work involving the rapid solidification of liquid droplets: metallic, ceramic, and polymeric, and their subsequent consolidation. A remarkable array of new amorphous and crystalline structures has been produced by these techniques with a corresponding variety of novel or much improved properties. Now more attention has been focused on the exploitation of all this new knowledge to produce materials of value to developing industrial technologies.

In the last year or two there has been a resurgence of interest in semiconductor materials of all kinds, but particularly on the still-developing technologies based upon silicon. In collaboration with faculty of other Departments we are planning a substantially increased effort in this field over the next few years. Many other areas of Materials Science and Engineering in which we have had strong research efforts for many years continue to prosper. There simply is not space to discuss or even list them here. Perhaps at no time in its history has there been such a ferment of ideas covering such a wide spectrum of the Department's intersts. We believe this provides a stimulating atmosphere in which our graduate students acquire the knowledge and skills they will need in their future careers.

Faculty

In January 1982, we were shocked by the sudden and untimely death of Professor Roy Kaplow at the age of 49. Professor Kaplow devoted all of his professional life to the Department and the Institute. His research and teaching were an essential component of our graduate program in Materials Science, which he had done much to formulate and translate to reality. The enormous debt which the Institute owes Professor Kaplow for his many years of unselfish and brilliant effort on our behalf was acknowledged in a special resolution by the Institute faculty.

There were a number of changes in the faculty of the Department. We were happy to welcome Dr. Linn W. Hobbs (electron microscopy and physical ceramics), who was appointed to an associate professorship; Dr. Gretchen Kalonji (materials processing), who was appointed to the Norton Assistant Professorship; and Dr. Ronald L. Ballinger, who holds an assistant professorship jointly with the Department of Nuclear Engineering. Professor Roland M. Cannon will be leaving at the end of the academic year to take up an appointment on the faculty of the University of California at Berkeley, where he will continue his excellent work on the brittle fracture of ceramic materials.

Professor Merton C. Flemings, Jr., was appointed to the newly established Toyota Professorship of Materials Processing. Professor H. Kent Bowen was named to a Ford Professorship of Engineering. Professor John F. Elliott was awarded a Distinguished Professorship by the American Iron and Steel Institute. To complete this unusually long list of appointments to chairs, Professor Samuel M. Allen was appointed to the ARCO Assistant Professorship which was created in the Department earlier this year.

Professor Walter S. Owen's tenure of office as Head of the Department of Materials Science and Engineering will terminate on August 31, 1982. Next academic year, he will devote his attention to teaching and research in physical metallurgy. Professor Flemings will succeed him.

As in previous years, the faculty of the Department received many honors and awards. Two are worthy of special mention: Professor Robert W. Baluffi was elected to the National Academy of Science, and Professor Julian Szekely was elected to the National Academy of Engineering.

Future Plans

The Department is now larger and its members more active over a broader range of interests than at any time in its history. However, we feel that careful thought must be given to the developments which will be needed to meet the challenges of the future. Different committees are discussing possible undergraduate curriculum developments, changes in our graduate programs in Metallurgy, Materials Science, and in the interactions between the programs, and the possibility of launching a new program in Electronic Materials. In the latter development, we will establish a close working relationship with our colleagues in the Department of Electrical Engineering and Computer Science. There will be many discussions with students, faculty in other departments, our industrial friends, and with other leaders of national projects before clear plans emerge and we move to implement them. The only thing which is certain at present is that we will do our best to ensure that our Department will be in the forefront of developments in Materials Science and Engineering in the next decade as it has been in the last.

WALTER S. OWEN

Department of Mechanical Engineering

This is my last annual report as Head of the Department of Mechanical Engineering, since I am relinquishing the position to accept appointment as Associate Dean of the School of Engineering effective September 1, 1982. In light of this change, it seems appropriate to begin this report with some overall remarks on the Department and its accomplishments.

The past eight years during which I have been Head have been a time of rapid expansion in students, faculty, and research activities, and of numerous new initiatives and developments in the face of serious financial constraints. It has been an extremely exciting time as mechanical engineering once again has been recognized as important and essential to the nation, but it also has been frustrating owing to exiguous resources. Nevertheless, the full-time regular faculty (as of July 1, 1982) has been increased by about 20 percent to 61 (including two vacancies to be filled in 1982-83), and has been further augmented through the addition of three part-time lecturers who are practicing designers, one adjunct professor, one senior research scientist, three senior lecturers, one senior research associate, and three senior faculty from other MIT units, all of whom teach part time on a regular basis. The undergraduate population increased from 179 in 1973 to 385 in 1981, while the regular graduate enrollment grew from 233 to 403. With nearly 800 graduate students, the Department is now the second largest at MIT.

Similarly, sponsored research has grown from about $4 million to an estimated $17 million, a real increase of about a factor of 2.4. It is notable that most of this growth has occurred via research sponsored through the interdepartmental centers and laboratories. In 1973, the Department had little interaction with such units, while in 1982, about two-thirds of its research goes through these organizations. Strong ties now exist with the Energy, Artificial Intelligence, and Electric Power Systems Engineering laboratories; the Centers for Policy Alternatives, Transportation Studies, Materials Science and Engineering, and Materials Processing; the Laboratories for Manufacturing and Productivity, and Information and Decision Systems; the Mining and Minerals Resources Research Institute; the Harvard-MIT Division of Health Sciences and Technology; and the Innovation Center. These interactions across the Institute have greatly enriched the research and educational programs of the Department, and have made possible new directions which otherwise could not have been undertaken.

In my first year as Head, I appointed a Department planning committee, chaired by Professor Joseph L. Smith, Jr., which in March 1976 published a report which has provided excellent policy guidance during the past six years. The Committee articulated Departmental goals in education, advancement of the field, and public service; recommended that research efforts be concentrated in four major programmatic areas (energy and environment; biomedical engineering; manufacturing, materials, and materials processing; and human services, including transportation); and suggested initiatives in the areas of graduate curriculum, industry cooperation, interaction with interdisciplinary centers and laboratories, personnel development, and major new facilities.

The innovations and accomplishments of the faculty and staff of the Department during the past eight years are truly remarkable in light of the very heavy student loads, increasing administrative complexity, shortages of funds and space, and slow salary growth compared with the cost of living. Among the more notable developments have been:

1) Assessment and reshaping of the graduate curriculum to establish core, advanced disciplinary, and professional subjects, and the establishment of an English writing requirement for all graduate students.

2) Formation and growth of the Laboratory for Manufacturing and Productivity, now a School of Engineering laboratory, which has already had a national impact on the stimulation and revitalization of activity in manufacturing in academic departments across the nation. This Laboratory, started in the Department and led by Professor Nam P. Suh, involves over 75 graduate students and 25 faculty members from six academic departments and has an estimated research volume of about $12 million, two-thirds of which comes from industry.

3) Development and expansion of the Joint Computer Facility, which now serves local research and educational computational needs of four academic departments, provides special capabilities for interactive graphics, and supports several important Department subjects in computer modeling, system dynamics and control, real-time computation, and introductory programming.

4) Broadening of research in energy to place greater emphasis on extraction and efficient utilization. New initiatives in this area have included building capability in extraction of natural resources (coal, oil, and shale), energy conservation, and low-emission combustion. Notable are the new Departmental Laboratory for Mining Systems Development and the activities of the Sloan Automotive Laboratory in spark and diesel engine performance and the interdepartmental program in fluidized bed combustion; the new REMERGENCE Laboratory which combines Mechanical and Civil Engineering activities in resource extraction, geotechnical, and construction engineering; and the recently established Program for Energy-Efficient Buildings and Systems which is joint with the Department of Architecture and the Energy Laboratory.

5) Strengthening the activities in engineering design. Following significant attrition in the late 1960s and early 1970s, the faculty was expanded and initiatives taken in the area of computer-aided design and graduate curriculum in design. New developments in the teaching of undergraduate design have gained nationwide attention and undoubtedly have been a factor in the rapid growth of student enrollment in design in recent years (much more rapid than the overall Department enrollment). New state-of-the-art Computer Aided Design (CAD) equipment has been secured and an active, industrially funded, and rapidly growing research program is in place in the newly formed Computer-Aided Design Laboratory under the direction of Professor David C. Gossard. Several important new graduate subjects have been developed, the most notable of which are 2.157 Computer-Aided Design, and the companion subjects 2.731 Advanced Engineering Design and 2.732 Advanced Design Projects, which feature work with sponsoring companies on the design and fabrication of real hardware, under the direction of Professor Warren P. Seering. Efforts are under way to secure capital funds for the development of a Center for Engineering Design which will provide the physical and computational environment needed for further development of design education and research.

6) Maturing and refining of biomedical engineering. During the years, this area has stabilized at about 20 percent of the Department's research activity and has become well recognized as a field of specialization within the profession. The most extensive development has been the construction in 1980 of the Eric P. and Evelyn E. Newman Laboratory for Biomechanics and Human Rehabilitation. Under the leadership of Professor Robert W. Mann, this Laboratory now is perhaps the premier facility in the world concerned with applying technology to aid the physically handicapped. Professor Padmakar P. Lele's Laboratory for Medical Ultrasonics has moved into the

field of cancer treatment by hyperthermia and has demonstrated dramatic results in reducing otherwise inoperable tumors. This success has led to major expansion of the activity in collaboration with area hospitals. Expanded research in artificial skin under the leader of Professor Ioannis V. Yannas has led to the practical realization of artificial membranes for replacement of human tissue, notably skin of seriously burned people. Faculty in the Fluid Mechanics Laboratory have made impressive progress in understanding the mechanics and physiology of fluids flowing in human tissue, with practical applications to thrombosis prevention, and understanding and detecting atherosclerosis and glaucoma. Research under Professor Ernest G. Cravalho on controlled freezing and thawing of tissue led to a practical method of preserving human blood.

7) Strengthening and expanding basic research in fatigue, fracture, and wear of materials. Under Professor Ali S. Argon, a first-rate computer-controlled materials testing laboratory was developed, and research conducted by this group has had extensive international impact. Similarly, under Professor Suh, an extensive program on wear was mounted and has led to important new theoretical developments such as the delamination theory, as well as practical solutions to numerous difficult wear problems.

8) Development of capability in real-time computation and control and microelectronics as an integral part of the systems and design discipline in mechanical engineering and creation of graduate subject offerings. Notable in the development are Professor Derek Rowell and colleagues of subject 2.161 Computer-Controlled Experimentation, and Profesor Paul K. Houpt of 2.171 Analysis and Design of Computer Control Systems. Both of these faculty have doctorates in electrical engineering.

During the last eight years the composition of the faculty has changed appreciably. Of the present active faculty about half have been appointed during the period. Seven faculty received tenure, and eight faculty were promoted to full professor. To broaden the skill mix in the Department, new appointments of individuals with the following backgrounds were made: civil engineering (2), electrical engineering (2), kinematics, life sciences, or applied mathematics (2), finite element analysis/civil engineering, and materials science. Owing to the relative youth of the senior faculty and the new age 70 retirement law, there were only three retirements. One senior faculty member resigned. The ratio of tenured to untenured faculty dropped from 0.63 in 1973-74 to 0.58 in 1981-82.

Prospects for the Future

Mechanical engineering, with its broad disciplinary base and strong design orientation, is one of the most versatile and pervasive of the engineering professions. It deals generally with systems (including living systems) and devices for the conversion of energy and the control of motions, forces, and material flows. The future prospects for the profession have never been brighter. Mechanical engineers have a vital role to play in the solution of virtually all of the most serious challenges and problems society faces in the years ahead, whether they be in the secure supply and efficient utilization of energy, health care and human rehabilitation, industrial productivity, protection and enhancement of the environment, safe and efficient transportation, utilization of space and the oceans, production of food, or national defense.

The prospects for the Department are similarly bright, even though difficult financial times lie ahead. The faculty is outstanding -- unmatched in stature and accomplishments of any department in the world -- and is especially rich in terms of its junior faculty upon which the Department depends for its future leadership and preeminence. These critical resources must be carefully nurtured and supported.

UNDERGRADUATE PROGRAM

Following growth by about a factor of three during the 1970s, undergraduate enrollment dipped slightly to 385 after remaining stable at about 400 for the last three years. However, sophomore enrollment in the fall of 1981 rose to 130 compared with 119 in 1980 and 118 in 1979. Of the 130 sophomores, 31 are women (five black) and 10 are black, representing 23.8 percent and 7.7 percent of the class, respectively. For the undergraduate population as a whole, 21.8 percent are women and 15.3 percent are minoritites, including the first American Indian to register in the Department.

Thirty-three of the minority students are blacks (including 12 women), representing 7.7 percent of all undergraduates.

In 1981-82, the Department awarded 109 S.B. degrees in Mechanical Engineering (accredited by the Accreditation Board for Engineering and Technology) of which 19 were in the Engineering Internship Program (Course II-B). In addition, 12 S.B. degrees without specification (Course II-A) were granted to students who completed specially designed programs combining study in mechanical engineering with other disciplines to prepare for careers in such areas as biomedical engineering, management, health services, law, medicine, or energy policy. Five of the 15 seniors in Course II-A were awarded double degrees with another department, several completed the five-year program in four years.

Undergraduate Subject Development

Professors Argon, Lallit Anand, and Frank A. McClintock are restructuring and developing the core sequence 2.31 and 2.32 Mechanical Behavior of Materials I and II. These subjects, which also have a new and refurbished laboratory associated with them, will provide a strong understanding of the deformation and fracture behavior of metals, ceramics, polymers, and composites, and provide a basis for the application of such materials in design.

Professor Thomas B. Sheridan developed 2.18J Human Factors in Design, which will be joint with the Departments of Nuclear Engineering and Psychology, to provide students with a practical understanding of the principles of human factors engineering in the design of systems involving human operators or users.

Professor Nathan H. Cook finished an important new textbook, *Mechanics and Material for Design*, which is being used in teaching solid mechanics to sophomores using microcomputers. With Professors Suh, Bruce M. Kramer, and other colleagues, Professor Cook is revising 2.86 Manufacturing Processes and preparing a new text. The objective of this subject is the development and presentation of the science base of manufacturing and familiarization with the manufacturing environment. This text should fill an important need in undergraduate manufacturing education.

Professor Mann and Dr. Michael J. Rosen developed an undergraduate seminar, S33 Biomechanics and Human Rehabilitation. The objectives of the seminar are to demonstrate how contemporary engineering analysis and experimentation can lead to functional models which describe human movement in health and disease, and to show how these models can be used both to understand and improve human performance through training or through mobility and sensory aids.

Student Organizations

Membership in the American Society of Mechanical Engineers (ASME) student section exceeded 50 percent of our undergraduates for the first time under the leadership of Helen M. Fray, president, and Professor Kramer, faculty advisor, due substantially to a very active programming activity.

Black ME, the organization of black students which helps to recruit minorities into the Department and provide a supportive environment and career guidance for them, completed the installation of a remote-entry computer terminal in the lounge which was used extensively by the membership. Nathan Graham was president and Professor Stephen H. Crandall continued as faculty advisor.

The student honor society, Pi Tau Sigma, continued to serve the Department through its vital course and instructor evaluations, and by organizing regular Friday afternoon student-faculty social hours and other special events. George J. Lombardo was president and Professor Seering served as faculty advisor.

Student Awards and Accomplishments

John J. Keane received a Department Service Award for his outstanding contributions to Pi Tau Sigma's activities and the Freshman Open House. The Department's major award for outstanding ingenuity and creative judgment, the de Florez Prize, went to two students this year: Richard J. Tello, for the design and construction of a continuous noninvasive extracorporeal blood-pressure-monitoring device; and George J. Dvorak, Jr., for the design and construction of an air-bearing table.

Three seniors were elected to the national honor society Phi Beta Kappa: Barry N. Cheskin, Mary E. David, and Stephanie L. Pollack. Three sophomores received highly attractive industrial scholarships: Thomas C. Davis and Galen E. Ressler were selected as Eastman Kodak Scholars, and Karen E. Welch was chosen as a General Motors Scholar.

Charles Frankel, a senior and president of the Class of 1982, received a Karl Taylor Compton Prize for his service to the class, his fraternity, the Social Council, homecoming, the ASME, and the Shakespeare Ensemble. The Frederick Gardiner Fassett, Jr., Award, recognizing spirit, dedication, and service in furthering the ideals of the MIT fraternity system, was presented to senior Thomas A. Lawton. The Albert G. Hill Prize, which honors minority students for contributions to the improvement of the quality of minority student life, went to Nathan Graham, a senior and president of Black ME, and to Norman L. Fortenberry, a junior and president of the MIT Chapter of the National Society of Black Engineers.

GRADUATE PROGRAMS

Enrollment in the graduate school increased by only six percent to 403, following a 13.5 percent growth from 1979-80 to 1980-81. Applications from both US and foreign students increased by about 13 percent this year, representing a 25 percent increase over 1978-79 and the previous several years. Of 351 students admitted, 178 registered. Of these, 151 are US citizens (58 are MIT graduates) and 27 are foreign.

The Department awarded 116 S.M.s (of which four were combined S.B./S.M.s), four Mechanical Engineer, and 19 doctoral degrees in 1981-82, nearly equal to the number of degrees granted the previous year.

About 43 percent of the graduate students were supported by the Department through research and teaching assistantships-about the same as in 1980-81. Overall, about 85 percent of all graduate students received support from the Department, MIT funds, fellowships, or employers -- down from 90 percent the previous year.

Graduate Curriculum Development

Subject 2.181J Man-Machine Systems was revised and the content changed by Professor Sheridan and Professor Laurence R. Young of the Department of Aeronautics and Astronautics to form the new subject 2.181J Models of Man-Machine Systems. A new joint subject 2.58J Radiative Heat Transfer was developed from a previous departmental subject by Dr. Leon R. Glicksman in cooperation with Professor Adel F. Sarofim of the Department of Chemical Engineering. Professors David M. Parks of this Department and Regis M.N. Pelloux (Department of Materials Science and Engineering) revised 2.34J, now retitled The Mechanics of Fracture, to upgrade it to graduate level.

As part of the development of a coherent graduate program in manufacturing, initiated in 1981-82, another new subject, 2.810 Advanced Manufacturing Processes of Metals, will be offered in 1982-83 by Professors Cook and Kramer. This subject will develop a fundamental understanding of the manufacturing parameters that affect the economics of production and the ultimate performance of parts produced from metals. Emphasis will be placed on the application of fundamentals to the identification and solution of critical problems in metals processing.

Professor Klaus Jürgen Bathe published a major new textbook this year entitled *Finite Element Procedures in Engineering Analysis* (Prentice Hall) which will serve as a text for the graduate subjects he has developed in this field.

Student Awards

Bharath S. Bagepalli received a Department Service Award for excellent performance as a graduate student teacher. Four students advised by Professor Seering, Tomas Ubach-Barrera, Carl P. Taussig, Kevin P. Tyra and Erik G. Vaaler received the James F. Lincoln Arc Welding Foundation, Division II Mechanical, Fourth Award for their paper, "A Gothic Groove Ballbearing Hone."

RESEARCH

The total volume of sponsored research for 1981-82 is estimated at about $17 million, 10 percent higher than in 1980-81, representing approximately $290,000 per faculty member. This year an estimated 66 percent of this research will be managed through the interdisciplinary centers and laboratories, continuing the trend of the past several years.

The Department's sources of research are highly diversified, coming from a wide spectrum of government agencies and industries. Some research groups such as the resource extraction group in the REMERGENCE Laboratory, the Sloan Automotive Laboratory, the Innovation Center, the Laboratory for Mining Systems, and the Laboratory for Manufacturing and Productivity derive from 50 to 100 percent of their support from industrial sponsors. As certain government sources of funding have been significantly curtailed, for example the Environmental Protection Agency (EPA), The Department of Energy (DOE), and the Department of Transportation (DOT), this diversity has been and will continue to be a great advantage to the Department.

During the past year much of the sponsored research in the environmental area has been phased out, or will be at the end of this fiscal year. Fortunately much of this type of research had already been terminated and the faculty involved had shifted to other areas. Nevertheless, some serious disruptions in research have already been experienced by faculty and graduate students, and more can be expected as Federal research cutbacks continue in the coming fiscal year.

Several companies and company foundations continued to make grants of unrestricted funds to the Department. In the continuing environment of financial stringency at the Institute, the Department depends almost entirely on this source of discretionary funds to seed new ventures not yet recognized as important by conventional funding agencies, to enhance the career development of junior faculty, and to acquire critical items of equipment for research or education. The Department has made excellent use of these funds, and they have paid off in terms of new initiatives and large externally funded programs far beyond the dollar values of the gifts. The Department particularly appreciates two new gifts this year: the TRW Foundation Faculty Fellowship, and the IBM Departmental Grant based on excellence in materials and manufacturing research.

Research in the Department covers a wide spectrum from basic fundamental research to the conception, design, and prototype evaluation of innovative systems to serve the needs of society. A significant fraction of the research involves hardware design and/or laboratory evaluation of physical systems, and in many cases is done in collabotation with industrial clients.

Approximately half of the faculty is explicitly involved in basic research, and almost every research project in the Department has at least some fundamental research content. In applications-oriented research, the percentages of faculty involvement in the four major current program areas of manufacturing and processing, energy and environment, biomedical engineering, and systems including transportation are approximately 33 percent, 47 percent, 22 percent, and 18 percent, respectively.

New Programs

In biomedical engineering, impressive progress was made in programs related to human mobility and sensory aids, treatment of tumors via hyperthermia, artificial skin, and biofluid mechanics.

The Eric P. and Evelyn E. Newman Laboratory for Biomechanics and Human Rehabilitation provided an environment for unique research in mobility, joint mechanics, and movement control. Professor Mann and his students completed the TRACK system for capturing body-segment kinematics and foot-floor interaction of the moving human, and an exclusive license was negotiated by MIT for commercialization of the associated software. In the complementary NEWTON computer program, also developed in the Laboratory, joint forces and moments are derived and optimally fitted to a model of the human leg with 36 muscles and nine degrees of freedom for the ankle/knee/hip joints, thus non-invasively deriving information on individual muscle timing and force levels. In addition to TRACK/NEWTON applications to normal and pathological human gait and muscle action, limb prostheses, and athlete studies, the system is being used to study blind mobility aids and as a possible means of augmenting the aesthetic appreciation of the dance. In addition, data obtained through ultrasonic determination of the detailed geometry and constitutive properties of the

human hip are illuminating the developmental biology of synovial cartilage and bone ossification, leading to identification of the likely contributions of mechanical factors alone, and of the mechanically-induced biological factors on osteoarthritis.

Professor Neville Hogan's research coupling the neurophysiology of movement control in primates and his analysis of the role of mono- and bi-articular muscle impedance control of human joints (both normal and prosthetic) is advancing both the understanding of how the brain controls movement and the prospects for prostheses controlled by the central nervous system, which approach the versatility and controllability of the normal limb.

In the Laboratory for Medical Ultrasonics, Professor Lele continued to demonstrate dramatic results in the reduction of otherwise inoperable superficial tumors through controlled hyperthermia introduced via focused ultrasound. Heat applied in this manner kills cancer cells without damage to healthy tissue and also can enhance the effectiveness of chemotherapy or radiation therapy. A major three-year, hospital-based clinical evaluation of hypothermia treatment has now been initiated with physicians and researchers at several area hospitals and medical centers.

In the area of artificial skin, Professor Yannas and his collaborator at the Shriners Burns Institute, Dr. John F. Burke, continued to perfect the multilayer artificial membrane as a temporary skin substitute, and engaged in negotiations for commercialization.

Professor Roger D. Kamm continued his investigation of high-frequency pulmonary ventilation in the Fluid Mechanics Laboratory. Recent experiments conducted on test animals produced the unanticipated result that high-frequency, low-volume ventilation (HFV) introduced at the mouth is capable of maintaining adequate respiratory gas exchange. This finding is exciting, since it suggests that HFV has the potential to become an entirely new and much less cumbersome mode of breathing assist in patients suffering from a variety of respiratory ailments.

In manufacturing and processing, the Department's major activities are associated with the Laboratory for Manufacturing and Productivity. The new programs which most strongly involve the Department are the robotics program, and a new initiative in tribology. The new initiative in robotics launched last year under the leadership of Professor Hogan, which is coordinated with the Artificial Intelligence Laboratory, the Laboratory for Manufacturing and Productivity, and the Departments of Mechanical Engineering and of Electrical Engineering and Computer Science, has been very successful. Professor David E. Hardt, Professor Seering, and new faculty appointee Professor Haruhiko Asada are participating in this effort. Substantial industrial support for the program is now available, and negotiations are under way to acquire on loan a new IBM RS-1 six-degree-of-freedom robot which will be installed in the new robotics laboratory space in the Laboratory for Manufacturing and Productivity.

The new tribology initiative, under the leadership of Professor Ernest Rabinowicz, is forming an industrial consortium to support basic and applied research aimed at solving problems in wear and developing new materials and composites which will significantly reduce wear.

Funds were acquired for the purchase of a dedicated computer facility for the new Machine Dynamics Laboratory which is under the direction of Professors Richard H. Lyon and Seering. Professor James E. Hubbard, Jr., who joined the Department this year, will also be associated with this Laboratory. Research in this facility is concerned with developing the technology needed to design future generations of high-performance automated machines and related systems.

The area of energy and environment involves about half of all Department faculty and accounts for a major portion of all sponsored research. During the year, progress was made in the relatively new programs in energy conservation in built structures, in resource extraction and mine automation, and in a new initiative that was launched in the area of heat transfer in solid-state electronics. In addition, the Sloan Automotive Laboratory established an industrial consortium to support research on internal combustion engines.

The proposed coherent research program in the development of new energy conservation techniques and design methods for buildings evolved into a formal proposal to the Deans of the Schools of Architecture and Planning and Engineering to establish a program for energy-efficient buildings and systems under the leadership of Senior Research Scientist Leon Glicksman. This proposal has been approved by the MIT administration and seed funds have been granted for initiation of the joint program between the Departments of Architecture and Mechanical Engineering. The

primary goals of the program are to develop basic technologies related to energy use in buildings; to disseminate research to industry, architects, and regulatory agencies; and to provide students with a solid foundation in the principles of energy efficiency for buildings. Currently 30 graduate students and 10 faculty members in the two Schools are engaged in research in this field.

During the past year the proposed joint Mechanical/Civil Engineering facility for experimental work in resource extraction, geotechnical, and construction engineering, known as the REMERGENCE Laboratory, gained the approval and financial support of the Dean of Engineering. Seed funds have been approved and a plan is now being formulated for raising the capital funds needed to create the proposed research and teaching laboratory facility. The principal faculty involved in this initiative are Professors Jerome J. Connor, Jr., and Herbert H. Einstein of the the Department of Civil Engineering, and Professor Cleary of this Department. The major mechanical engineering activity which will benefit from this facility is Professor Cleary's project MIT UFRAC --on theoretical and laboratory simulation of underground fractures, which is currently sponsored by 16 major energy companies.

A new Laboratory for Mining Systems Development has been established by Professor Carl R. Peterson to explore the opportunities for innovation in the mining industry through an interdisciplinary approach. The major activity at present is an industry-funded program to develop remote-control underground mining systems. This year, four graduate students were investigating mine roof behavior, concepts for mining machine guidance, cutting action monitoring systems, and roof support systems suited for remote and automated operation.

Under the leadership of Professor Borivoje B. Mikić, a new program, centered in the Heat Transfer Laboratory, was initiated in the area of heat transfer in electronics. Initially, emphasis is being placed on the relationship between thermal effects and the quality of crystals which can be produced.

Professor John B. Heywood, director of the Sloan Automotive Laboratory, led the successful development of an industrial consortium, which will support an expanded and broadened program of engine research. Initially, the consortium will focus on studies of flow and combustion inside engines and on establishing the relationship between fuel quality and combustion processes in diesel engines. Through the consortium, the Laboratory will also expand its work in the areas of engine lubrication and friction, and engine and transmission system dynamics and control.

In Systems including Transportation, notable progress occurred in three laboratories: The Man-Machine Systems Laboratory, the Vehicle Dynamics Laboratory, and the Computer-Aided Design Laboratory. The research objective of Professor Sheridan in the Man-Machine Systems Laboratory is to augment human operators in controlling machines to improve system performance and safety and reduce costs. During the year, research progressed on the design of remote-control schemes for deep-ocean manipulators and vehicles, in cooperation with the Naval Ocean System Center of San Diego. Research also progressed with the Woods Hole Oceanographic Institution to build a bottom-following control for their "Alvin" submarine. Other research is aimed at developing methods for detecting and locating failures in nuclear plants or aircraft by comparing measured power flows at various points in the system with computed values in a computer model of the same system.

The Vehicle Dynamics Laboratory, directed by Professors David N. Wormley and J. Carl Hedrick, continued to shift its major emphasis toward rail vehicle performance and safety and handling characteristics and engine control of automobiles and trucks. In the past year, research has been pursued to evaluate active and passive control systems for rail passenger car lateral suspensions, and a new program was initiated on advanced catenary-pantograph systems for electric power collection in passenger and freight applications. Technical studies under Professor Houpt during the year focused on the development of dynamic models of spark and diesel engines suitable for closed loop controller design.

Professor Gossard and his associates in the Computer-Aided Design Laboratory continued to expand research activities and computing facilities, focusing on advancing the state-of-the-art in computer-aided design and interactive graphics, both for professional practice and as an educational aid. This activity is fully funded by industry. Notable this year was the highly successful MIT Conference on CAD/CAM Technology in Mechanical Engineering, which attracted several hundred professionals from industry, academia, and government. The conference was organized by Dr. Fontaine Richardson, senior lecturer in Mechanical Engineering.

FACULTY AND STAFF

In October 1981 there were 55 active faculty: 27 professors, 17 associates (five with tenure), and 11 assistant professors. Three assistant professors joined the Department in January, and one full and one assistant professor will join on July 1. One full professor was added by transfer from the Department of Ocean Engineering, and one associate professor resigned. As of July 1, the Department will have a total active faculty of 59, and two vacant positions.

There were nine minority faculty (two blacks -- one professor and one assistant professor -- and seven Asians) and one woman associate professor, plus a woman adjunct professor who also held an appointment as senior research scientist.

Of the seven administrative and exempt staff, five are women. All of the support staff are women, two of whom are black. Among 18 hourly staff, three are black.

Accomplishments and Awards

Professor Emeritus, senior lecturer, and former Head of the Department Jacob P. Den Hartog was honored by the Government of Japan with the Third Class of the Order of the Rising Sun. The Order was presented by the Consul-General of Japan in Boston at Den Hartog's home. In his congratulatory remarks, Chairman Howard Johnson commented on the special relationship between Japan and MIT which Den Hartog had helped to foster and noted that the history of MIT was written in the biographies of its great professors.

Ascher H. Shapiro, Institute Professor and former Department Head, received the 1981 Fluids Engineering Award of ASME.

The University of Cape Town, South Africa, conferred on Professor Bathe the honorary degree of British Doctor of Science in Engineering, a distinction given only twice before in the history of the university. He was also the 1981 recipient of the Walter L. Huber Research Prize of the American Society of Civil Engineers.

Dr. George N. Hatsopoulos, senior lecturer and president of Thermo Electron Corporation, received the degree of Doctor of Science, Honoris Causa, from the New Jersey Institute of Technology.

Professors Kramer and Suh won the ASME Blackall Award for their research leading to the development of a quantitative theory of tool wear based on the chemical properties of the tool-work system.

Robert W. Mann, Whitaker Professor of Biomedical Engineering, was elected to the National Academy of Sciences. He also became a Fellow of the American Association for the Advancement of Science.

Professor Parks received a Graduate Student Council Award for Outstanding Graduate Teaching.

Professor Seering won a 1981 Ralph R. Teetor Educational Award of the Society of Automotive Engineers.

Professor James H. Williams, Jr., was selected as the first recipient of the new J.P. Den Hartog Distinguished Educator Award in Mechanical Engineering. The award was made on the 80th birthday celebration of Den Hartog, on July 23, 1981.

New Faculty

Five new assistant professors joined the Mechanics and Materials Division of the Department. Dr. Triantophyllos Akylas, who received his doctorate from the Department of Mathematics, is working in the areas of wave propogation, nonlinear dynamics, and fluid mechanics. Dr. Anand, who joined the Department from the research laboratories of the US Steel Corporation, is teaching in the undergraduate and graduate core in the mechanics of materials, and is collaborating in fracture mechanics research with Professors Argon and McClintock. Dr. Asada, formerly research associate in the Automation Research Laboratory of the University of Kyoto, Japan, will

be working with faculty associated with the Laboratory for Manufacturing and Productivity and the Artificial Intelligence Laboratory, in the area of robotics and automated assembly. Dr. Timothy G. Gutowski, a graduate of the Department, is teaching undergraduate subjects in mechanics and materials and shares responsibility for several new graduate subjects in manufacturing. He also serves as assistant director of the MIT-Industry Polymer Processing Program. Dr. Ming-Kai Tse, also a graduate of the Department, returned from a year of employment at American Can Company to take up research and teaching in manufacturing technology as American Can Company Assistant Professor. Professor Patrick Leehey transferred to the Department from Ocean Engineering.

One new assistant professor was appointed in the Thermal and Fluid Sciences Division. Dr. Gian P. Beretta, a graduate of the Department, is working on fundamental research on the foundations of thermodynamics, and is teaching and developing core graduate subjects in this discipline. Professor Beretta is being supported in part by a grant from the Thermo Electron Corporation.

In the Systems and Design Division, Dr. Hubbard was appointed assistant professor, following completion of his doctoral work under the supervision of Professor Wesley L. Harris, Sr. of the Department of Aeronautics and Astronautics. Professor Hubbard, who is a former Department instructor and recipient of the Goodwin Medal for outstanding graduate student teaching, is teaching undergraduate laboratory and system dynamics and conducting research in the general area of machine dynamics. Dr. David G. Jansson, associate professor and director of the MIT Innovation Center, transferred to the Department from Aeronautics and Astronautics.

Visiting Faculty

Dr. Richard E. Garrett, director of CAD/CAM Research at the Control Data Corporation, spent the year working part time as a visiting professor in collaboration with Professor Gossard.

Professor Naomasa Nakajima of Tokyo University joined the Computer-Aided Design Laboratory as a visiting associate professor where he taught graduate students and conducted research in computer-controlled mechanical systems.

Professor Helmut Kirchner of the University of Vienna was a visiting associate professor and research fellow. He taught in the area of physics of deformation and fracture and collaborated with Professor Argon in research on dislocation modeling based on the Bauschinger effect.

In addition to visiting faculty, the Department was host to 21 visiting engineers, scientists, and scholars, 18 of whom came from 10 foreign countries: six from the People's Republic of China, three from Japan, two from England, and one each from Australia, France, Greece, Israel, Korea, Romania, and Turkey.

Resignations

The resignations of Associate Professor Stephen B. Pope and Assistant Professor George E. Abouseif were accepted with regret. Professor Pope resigned in January to join the Mechanical Engineering Department at Cornell, and Professor Abouseif resigned in September for personal reasons.

A Note of Thanks

In concluding this report, I should like to express sincere thanks to all of the members of the Department and the MIT community who have been so helpful and supportive to me during my eight-year tenure as Head. I have found the leadership of this Department to be exciting and rewarding, due largely to the outstanding quality, dedication, and cooperative spirit of the faculty, staff, and students. I am grateful to those many colleagues and staff members who have served as members of the Steering Committee and other standing and special committees of the Department, as heads and staff members of our administrative and student-related offices, and in many other individual ways too numerous to mention. William J. Westcott, administrative officer, and his associate, Irvin F. Curtis, have been especially effective in managing the budget, space, and support personnel of the Department during a very challenging period of financial stringency combined with rapid growth.

A very special note of thanks to Grace H. Kelly, executive assistant to the Department Head, whose total dedication, meticulous attention to detail, knowledge of the Institute, and warm personal outlook have been invaluable both to me and to the Department as a whole.

Finally, I should like to thank the members of the Department Visiting Committee whose advice, counsel, and frank and constructive criticism have been of enormous value in helping to guide the course of the Department. Under the enthusiastic and active leadership of F. Richard Meyer III, the Committee has been one of the most effective Visiting Committees in my experience at MIT and outside.

HERBERT H. RICHARDSON

Department of Nuclear Engineering

Nuclear power activity nationally continues to be concentrated on maintaining successful operation of existing plants and completing a nearly equal number of plants now entering or under construction. Although the Federal administration continues to encourage nuclear development, new orders will depend upon resolution of two key problems adversely affecting the industry. These are: first, the licensing process uncertainties, which must be greatly reduced; and second, the financial condition of the utilities, which must be improved to enable them to raise the capital required for major building projects.

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 150 to 160 students. On the other hand, our undergraduate enrollment is currently 31 students, well below our goal of 70 to 80 students, even though 11 undergraduates chose nuclear engineering during the academic year.

During the past year, a new system of student recruiting was initiated, primarily for domestic students. In the face of the many adverse factors that might potentially decrease graduate enrollment, our graduate applications this year were equivalent to last year. Therefore, we believe our new recruiting system has been successful in reaching a sufficient number of excellent applicants who will maintain our desired enrollment level,

The Department awarded 47 advanced degrees including 19 doctorates, three nuclear engineers, and 25 masters of science during the academic year 1981-82.

The Engineering Internship Program, which offers undergraduates the opportunity to have significant 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 11 students -- three graduates, five seniors, and three juniors -- 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.

The Department has formalized its involvement in the biomedical sciences by creating undergraduate and graduate programs in Radiological Sciences. The undergraduate program, under the direction of Professor Alan Nelson, provides students with a strong engineering and physical sciences background for advanced work in radiological sciences, medical engineering, or medical school. The graduate program, under the direction of Professors Gordon Brownell and Nelson, is offered in conjunction with the Harvard-MIT Division of Health Sciences and Technology and includes specializations in radiation biophysics, medical imaging and therapy. This program was recently approved by the National Cancer Institute which funds the graduate trainees. In particular, the graduate program in Radiological Sciences takes advantage of local hospitals for more clinically related research.

Professor Nelson has introduced two new graduate courses and has revised an undergraduate subject. The graduate courses are Radiation Biophysics, and Innovation and Conceptual Design for the Solution of Technical Problems in Clinical Medicine. The undergraduate course, Radiation Effects and Uses, now includes material on radioisotope dating, cosmic radiation, medical uses, and radiobiology. In addition, Professor Nelson is running a graduate seminar in Biomedical Engineering.

A new experimental energy course, Case Studies in Energy Technology, Economics, and Management, was offered by the School of Engineering and the Sloan School during the 1982 spring semester. The goal of the course was to provide a focus for individual students, while working in groups, both to synthesize the information and methods of analysis acquired in other courses, and to develop new skills for coming to grips with the multidimensional nature of contemporary energy issues. The course was planned and coordinated by Professor David White and Dr. Marvin Miller of the Energy Laboratory and the Department of Nuclear Engineering. Also participating from the Department were Professors Michael Golay and Elias Gyftopoulos, as well as faculty from other departments of the School of Engineering and the Sloan School.

During the summer of 1981 the Department offered a Special Summer Session program on Nuclear Power Reactor Safety, directed by Professors Norman Rasmussen and Neil Todreas. This two-week program was attended by 187 people who represented all segments of the nuclear industry and 13 foreign countries. The Summer Session Program, "Man-Machine Interfacing in Nuclear Power and Industrial Process Control," was offered jointly with the Department of Mechanical Engineering by Professors David Lanning and Thomas Sheridan in June 1982. Approximately 30 people participated. During June 1982 Professor Carolyn Heising offered a new summer course, "Probabilistic Risk Assessment: Uses and Applications to Decision Making in the Nuclear Industry." Forty-nine people attended this new offering.

In cooperation with the Center for Advanced Engineering Study (CAES) Seminar Office, a three-day course on Advances in Nuclear System Thermal Analysis was offered during April 1982, under the direction of Professor Mujid Kazimi. Participants included outside lecturers as well as Professors Golay, Todreas, and John Meyer. It was attended by 60 people (including 11 from five foreign countries). The course received a very positive evaluation from those participating.

STUDENT ACTIVITIES

The MIT chapter of the American Nuclear Society (ANS) has completed another productive year. Activities have included student/faculty meetings, Departmental steak fries, course evaluations, participation in regional student conferences (at Georgia Tech and the University of Missouri at Columbia), and numerous engagements speaking to Boston-area groups concerning nuclear power issues.

Honors and Awards

The student chapter of the ANS received a national award in recognition of its aggressive and comprehensive program for dissemination of information to the public on the merits of nuclear power. This was the third consecutive year in which a public information award was received (1980, second; 1981, second; 1982, honorable mention for best all-around public information program).

At the ANS 28th annual meeting held in June 1982, the Verne R. Dapp Memorial Scholarship Award for excellence to a full-time graduate student in the field of nuclear engineering and science was presented to Alan Wan. At the same meeting, Roderick Jennings, an undergraduate, was named recipient of the John and Muriel Landis Scholarship Award for outstanding effort and academic achievement in pursuit of a college education despite severe hardships. Anthony O. Adegbulugbe was runner-up for the best student paper award (materials science and technology division) at the ANS 1981 winter meeting. At the Georgia Tech regional student conference, David Medek, an S.B. candidate, received the best student paper award from his division.

The first group of MIT members was inducted into Alpha Nu Sigma, a new national honor society

for nuclear science and engineering. Twelve undergraduate students (including Dave Petti, acting president) and 31 graduate students (including Paul Gierszewski, acting vice president) were inducted.

Several of our graduate students were recipients of national fellowships. The Department of Energy (DOE) Magnetic Fusion Energy Fellowships were awarded to Steven Piet and James Doyle for the 1981-82 academic year, and to Deborah Hanchar for the year beginning September 1982. Derek Ebeling-Koning and Richard Burke have been selected for the newly established DOE Nuclear Science and Engineering Fellowships. Beginning in September 1982, Vincent Manno will also be receiving a DOE NSE Fellowship. For both these national competitive DOE programs, the number of awards to MIT students reached the limit established for receipt by any one institution. A Hertz Foundation Fellowship was awarded to Thomas Downar.

Other Student Awards

During the academic year, approximately 63 percent of our graduate student body was appointed to the graduate student staff, receiving financial aid in the form of research and teaching assistantships. In addition, Ronald Ballinger and Peter Roemer received the graduate Instructor G appointment. The Department was pleased to award the Theos J. Thompson Memorial Fellowship to Hussein Khalil. The Sherman Knapp Scholarship, funded by Northeast Utilities, was awarded to Stephen Primeau. Two fellowships were awarded to Meta Brown and Bruce Hagemeier from funds provided by the Institute of Nuclear Power Operations member utilities. The Department was awarded two MIT-endowed tuition scholarships. Students selected for one term of support were Vincent Manno, Heidi Wyle, Reza Najafabadi-Farahani, and Jean-Marie Noterdaeme.

RESEARCH

The Department conducts research in the areas of applied radiation (radiation physics and biomedical), energy policy, fission (reactor engineering, reactor physics, and reactor materials), and fusion (theory, experimental plasma, technology, and fusion materials). During the fiscal year ending June 30, 1982, Department faculty supervised a research volume of $2,633,820, including research funded through the Department, 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 1981 research volume in the Department was $1,073,172.

Professors Sow-Hsin Chen and Sidney Yip lead the Department's efforts in the area of applied radiation physics. Professor Yip continues to carry out theoretical studies on the dynamics of dense fluids. In the area of nuclear medicine, Professor Brownell continues his interest in the development of neutron capture therapy for the treatment of glioblastoma and other diseases. This work is in conjunction with the Nuclear Reactor Laboratory. At the Massachusetts General Hospital, Professor Brownell is active in many areas involving the development of positron tomography and its application in medical diagnosis and patient care. In the area of radiation biophysics, Professor Nelson has initiated several research efforts. In conjunction with the Nuclear Reactor Laboratory, the effects of thermal neutrons on biological materials are being examined. The work on neutron effects on red blood cells is also carried out at the Naval Blood Research Laboaratory where an ongoing research agreement has been established. The effects of ionizing photons and magnetic fields on embryos are being investigated in collaboration with the Twin Brooks Embryos Transfer Company and the Francis Bitter National Magnet Laboratory. The effects of ionizing radiation of vasculature are being studied in conjunction with the Harvard Medical School. This project is directed toward improved methods of tumor treatment. Professor Nelson also is initiating various investigations in microstructure of organisms and materials, and in laboratory automation and digital image analysis.

Professors Lanning and Meyer, working closely with Professor Sheridan and the Charles Stark Draper Laboratory staff, are active in the problems of the man-machine interface in a nuclear power plant control room; a demonstration project is currently under development at the MIT Research Reactor. Professor Richard Lester is continuing his research in the area of radioactive waste management and disposal. In the area of reliability analysis, Professor Rasmussen is studying

the economic consequences of nuclear accidents and the reliability of standby safety systems. During the past year Professor Heising has made considerable progress in the areas of common cause and human reliability analysis. Professor Gyftopoulos continues his work on the foundations of quantum thermodynamics, including a new equation of motion for quantum physics and the distinction between quantal and nonquantal uncertainties. He also continues his work on cost-effective methods for energy conservation.

In the area of reactor physics, Professor Allan Henry has continued his work on numerical modeling of the behavior of light-water moderated reactors. Professor Michael Driscoll has completed a DOE-sponsored research project evaluating core design and fuel management innovations to improve uranium utilization in Pressurized Water Reactors (PWRs); his work continues on the neutronic design of advanced fast breeder reactor cores. He and Dr. Frederick Best continue their research for the DOE on the extraction of uranium from seawater. The Department continues its broad activities in the area of thermal hydraulics and fluid flow. Professors Kazimi, Lanning, and Todreas, and Professors Golay and Meyer have contributed individually and jointly to studies of sodium boiling behavior in Liquid Metal Fast Breeder Reactors (LMFBR), 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 Lawrence Lidsky, along with Drs. Robert Potok and Dan Cohn of the Plasma Fusion Center, is involved in reactor design studies. He directs an experimental study of electromagnetic forces in fusion reactor structures, as part of Professor Kazimi's fusion reactor hazard evaluation study. He also is concerned with the rapidly evolving area of stellarator/torsatron physics. This work is part of a joint project with Professor Jeffrey Freidberg. Professor Freidberg also has been working in the area of plasma stability using magnetohydrodynamic (MHD) theory. In particular, he was involved in researching stellarators and tandem mirrors. Professor Meyer has been investigating first wall/blanket engineering of advanced resistive magnet Tokamaks. Professor Kazimi continues his studies of fusion reactor safety, with major emphasis on the development of a methodology for assessment of reactor design impact on safety.

Departmental research activity in the area of nuclear materials continues to grow. Professor Otto Harling has 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 Kenneth Russell is continuing his theoretical and experimental studies on defect aggregation in irradiated alloys, with emphasis on fusion reactor first-wall applications. Professor I-Wei 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. Professor Chen and Dr. Best are modeling the mechanisms by which a zirconium metal fire might develop and spread in a drained spent fuel storage pool.

Professor David Rose and Dr. Miller, together with Dr. Christopher Hill of the Center for Policy Alternatives and Professor Carson Agnew of Stanford University, are studying the technological and social options and consequences related to carbon dioxide build-up in the atmosphere. This work is supported by the National Science Foundation (NSF). Dr. Miller, along with Professor, Emeritus Manson Benedict and Professor George Rathjens, conducted a proliferation assessment of three advanced isotope separation methods for uranium enrichment for the US Department of Energy.

New Research

Several new projects have been initiated by Department faculty during the past year. Professors Kazimi, Meyer, and Heising initiated research in the area of PWR severe accident analysis under the sponsorship of the Electric Power Research Institute (EPRI). Professor Golay is working on hydrogen transport in nuclear containments; he also has initiated unsponsored research in the area of nuclear safety regulation principles and safety goal determination. Two research projects have been initiated by Professor Todreas: one in thermal hydraulics of fast breeder fuel assemblies, and the second in hydrodynamic prediction of multidimensional single and two-phase flow in rod arrays.

FACULTY

Ronald Ballinger was appointed as an assistant professor of Nuclear Engineering. The appointment is joint with the Department of Materials Science and Engineering. His activities will be in the fission reactor and fusion materials area.

The Department is pleased to announce that Professor Kazimi was promoted to associate professor with tenure and Professor Lester was promoted to associate professor.

The Department was happy to welcome the following visiting faculty during the 1981-82 academic year: Teymour Boutros-Ghali, plasma theorist, was appointed a visiting assistant professor of Nuclear Engineering from September 1981, through May 1982. Professor Boutros-Ghali concluded several research projects for and taught Plasma Kinetic theory on behalf of Professor Thomas H. Dupree, who was on sabbatical leave for the academic year. Visiting Associate Professor Gilbert Brown from the Nuclear and Energy Engineering Department at the University of Lowell was appointed from September through December 1981. During this period he participated with Professor Kazimi in the EPRI research project, Severe Light Water Reactor Accident Analysis. Subsequent to this effort, he was appointed research affiliate from January through June 1982. Philip Rosenau, senior lecturer, faculty of Mechanical Engineering, Technion, Israel Institute of Technology, was appointed visiting associate professor for eight months effective February 1982. He brings to our Department his expertise in the area of magnetohydrodynamics. With Professor Freidberg, he co-taught MHD Theory of Magnetic Fusion Systems II, which was offered for the first time in the spring term.

In addition to Professor Dupree, other Department faculty who were on sabbatical leave this academic year were Professors Lidsky and Sow-Hsin Chen, both for the fall term.

Professor Rose spent the spring semester at the Resource Systems Institute of the East-West Center in Honolulu, continuing an association between MIT and the East-West Center on Asian-Pacific problems of mutual interests, particularly those related to energy.

Professor Driscoll completed a five-year term of office as faculty chairman of the MIT Undergraduate Seminar Program. He was appointed recruiting officer to implement an enhanced effort to enroll more graduate and undergraduate students into Course 22. Professor Yip was appointed financial aid officer. Professor Golay has assumed responsibility for the nuclear technology portion of the Energy Lab's Electric Utility Program. Professor Nelson was appointed director of the MIT Whitaker College Laboratory of Microscopy. Professor Harling continues to serve as director of the interdepartmental Nuclear Reactor Laboratory. Professor Lanning continues as admissions officer and UROP coordinator for the Department. He is a member of MIT's Committee on Reactor Safeguard, the Safety Audit Committee at Northern States Power, and the Nuclear Safety Review and Audit Committee at Boston Edison.

Professor Rose served as chairman of an NSF workshop on Assessment of Basic Energy Research in the United States, with the objective of helping Federal organizations establish research priorities. He completed his work as a member of the Program Committee of the International Symposia series connected with the 1982 Energy World's Fair in Knoxville, TN, and was coauthor of the principal technological address and the final communication of the series.

Professor Kazimi serves as chairman of the Nuclear Heat Transfer Committee of the American Institute of Chemical Engineering. He is on the advisory committee of the DOE Fellowship for Magnetic Fusion Energy Technology. Professor Freidberg serves on the executive committee of the Stellarator Advisory Panel for the DOE. Professor Meyer served as Chairman of the Mathematics and Computation Division of the ANS. Professor Heising served as chairman of the Northeast Section of the ANS. She continues to serve on the national program committee of the ANS Reactor Safety Division, the NEED committee, and the ANS-Nuclear Regulatory Commission technical writing group on the Probability Risk Assessment Procedures Guide. She has been appointed technical program cochairman for the 1983 ANS Topical Meeting on Degraded Core Analysis, to be held in Cambridge.

Professor Rasmussen was appointed a member of the National Research Council Committee on Advanced Nuclear Reactors. He continues to serve as chairman of the MIT Committee on Reactor Safeguard, as well as chairman of the MIT School of Engineering Committee on Energy Systems. At the EG&G Idaho National Engineering Laboratory, he is chairman of the Scientific Review Committee, and chairman of the Fusion Safety Committee.

Professor Todreas serves on the editorial board of the thermal design section of the *Journal of Nuclear Engineering and Design*. The second edition of *Nuclear Chemical Engineering*, by Professor Benedict, with coauthors Thomas H. Pigford and Hans Levi, former members of the Department, was published by McGraw-Hill. Another McGraw-Hill publication, *Molecular Hydrodynamics*, was written by Professor Yip and Jean Pierre Boon. *Scattering Techniques Applied to Supramolecular and Nonequilibrium Systems*, edited by Professor S.H. Chen, Benjamin Chu, and Ralph Nossal, was published by Plenum Press in 1981.

Honors and Awards

Several of the Department faculty were recognized with honors during the past year. Professor Freidberg received the outstanding teacher award from the student chapter of the ANS. Professor Driscoll was co-recipient of the Institute's Irwin Sizer Award for 1982 for "the most significant contribution to MIT education" in recognition of his efforts over the past three years in the establishment of the Institute's new Writing Requirement. Professor Benedict received the Washington Award of the Western Society of Engineers.

This past spring Professor Hansen was elected to the National Academy of Engineering. Professor Todreas was elected to the ANS Board of Directors and the Executive Committee.

This is my first report as Head of the Department of Nuclear Engineering. This position has afforded me the opportunity to participate in the new administration of the School of Engineering, and to assess our academic and research programs and use of resources as we develop a new long-range plan for the Department. I expect the implementation of this new effort over the next five years to be an exciting time for both me and my colleagues.

NEIL E. TODREAS

Department of Ocean Engineering

This past year has been marked by an unusual level of introspection, self-evaluation, and projections by the Department of Ocean Engineering. These are ongoing functions, but they were greatly stimulated by two changes of Department Head and a new Dean during the past year.

Three parts of the Department's educational and research program are generally recognized as unique in the United States:

1) Our research and doctoral study programs encompass a broader spectrum of topics than any other US university program relating to engineering in the marine environment. Long-standing research efforts in marine hydrodynamics, ocean and ship acoustics, marine transportation systems, and ship-fabrication technology produced significant accomplishments during the year. Important new knowledge was produced in several of our less traditional areas, for example, dynamics of marine risers, effects of blowouts of underwater gas and oil wells on surface vessels, and the systematic clean-up of oil spills. Our graduate students were involved in all of these projects, and after graduation they are eagerly sought by industry, government, and other academic institutions.

2) The Naval Construction and Engineering Program (Course XIII-A) prepares engineering-duty officers of the US Navy (USN) for positions of leadership in the design, construction, and maintenance of USN ships and ship systems. In the past year, there were approximately 50 USN officers enrolled in this three-year program, as well as a few officers of the US Coast Guard and several foreign navies. These numbers have been fairly stable recently, but it appears that the US Navy's need for qualified engineering officers may increase the enrollment somewhat in the near future. Twenty USN officers started the program on June 1.

We are striving to increase the coordination between our Course XIII-A and the Naval Sea Systems Command (NAVSEA), which sponsors the officer-students. Recently, NAVSEA responded to these

initiatives by informing the Institute of its plans to fund a professorship in support of the Course, starting in the next fiscal year and continuing for at least five years. This support will augment the contributions of the two USN officers who are normally assigned to the Department as faculty members. Our intention is to use this opportunity to improve our research and teaching in the area of ship design. Such an effort will strengthen not only Course XIII-A but also our regular program for civilian students who are studying for professional careers in ocean engineering. As we develop the role of the new professorship, we look forward to closer cooperation with the Navy, with mutual benefits. We expect to exploit our increased capabilities to improve the Navy's design functions, and we expect to develop a broader research program in support of the Navy's missions; both accomplishments will, of course, enhance our own education and research programs.

3) In the Ocean Systems Management Program (Course XIII-B), studies are concentrated on problems, cencepts, and methodologies of the management of marine systems. The program differs from those offered, for example, by schools of business administration in its integration of economics, policy and politics, law, and management studies with the quantitative methodology and content of operations research and ocean technology. Students are admitted only if they have a degree or equivalent experience in ocean engineering or one of its subspecialties, such as naval architecture and marine engineering. Graduates of the program, who receive the Master of Science degree in Ocean Systems Management, find plentiful employment opportunities, especially in ocean transportation of the commodities on which the nation's commerce, energy needs, and defense depend.

Course XIII-B is now undergoing a major reorganization, which may well take a year to complete. The goals of the Course are not being changed, but we are working to improve our methods of reaching those goals. In particular, we want to achieve a tighter integration among the subjects taught in the Course and coordinate the Course better with related activities in other units of MIT, especially the Center for Transportation Studies, the Operations Research Center, and the Sloan School.

The undergraduate program remains the largest single problem in the Department. The most obvious symptom is our continuing inability to attract more than 10 to 15 students per year to the program. One major contributor to this situation is largely beyond our control: the existence and nature of the field of ocean engineering are practically unknown among precollege-age students. This is especially unfortunate in view of the tremendous opportunities that are available to graduates in this field. The recruiters who come to the MIT campus seeking ocean engineers tell us repeatedly that, because of the shortage of ocean engineers, they are forced to hire young people whose education does not adequately prepare them for the tasks of the profession. The design, construction, and operation of systems for the marine environment requires a special kind of education and attitude. The ocean engineer is characterized by a systems-oriented approach, with special cognizance of the peculiarities of the ocean environment. The nation needs a vastly larger reservoir of young ocean engineers with the appropriate educational background.

Since it is unlikely that our Department alone will be able to communicate this situation to American high-school students, we are seeking help in informing the public of the needs and opportunities in ocean engineering and considering alternative ways of producing well-educated ocean engineers. We are investigating with the Sea Grant Program the possibility of launching a national campaign, directed primarily at high schools, to advertise the career potential in ocean engineering. As an alternative method of delivering education in ocean engineering, we are evaluating the possibility of concentrating on the master's degree program for preparing entry-level ocean engineers. Such an approach would allow us to limit our outreach to the smaller population of the undergraduate engineering students; it would enable us to build on the fundamental education that such students receive in other disciplines, so that we could concentrate our resources on those areas that are unique to ocean engineering. It is urgent that we increase our output of ocean engineers for professional practice. It is not absolutely necessary that we do this through the traditional undergraduate study program.

Robert Bruce Wallace Prize and Lecture Program

The third Robert Bruce Wallace Academic Prize, for the 1982-83 academic year, will be awarded to Paul Eberhardt, Class of 1983. This Prize was 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 awarded to a student for demonstration of outstanding potential for success in ocean engineering, without regard to the students's financial need. The amount of the award covers 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. The purpose of the program is to bring advanced ideas in ocean engineering to the attention of students and faculty in the Department, the MIT community, and the public. The second annual lecture was presented on April 27, 1982 by Commander Clark Graham, USN, and Captain Henry Cox, USN (Retired), on "Technology of the Future Navy." Both speakers received doctorates from MIT and subsequently held key roles in the development of ships and ship systems for the US Navy.

FACULTY

Professor Ira Dyer resigned as Department Head after 10 years of service, so that he could devote his time to teaching and research in acoustics, vibration, and noise control -- fields in which he is widely recognized an an authority.

Professor Chryssostomos Chryssostomidis served as Acting Department Head from September 1, 1981, to February 1, 1982. T. Francis Ogilvie was appointed professor of Ocean Engineering and Head of the Department, effective February 1, 1982.

Lieutenant Commander Gary Kavanaugh, USN, joined the faculty as an associate professor of Ocean Engineering. In June, he was transferred to duty at the Naval Sea Systems Command, and he resigned from the faculty.

Joao G. de Oliveira was promoted from assistant to associate professor effective July 1, 1982.

Paul D. Sclavounos joined the faculty as an assistant professor of Naval Architecture.

Professor Ronald W. Yeung has resigned to accept a professorship at the University of California at Berkeley.

Professor Koichi Masubuchi was on sabbatical in the spring term as Visiting Distinguished University Professor at Ohio State University.

Professor J. Nicholas Newman was on sabbatical for the past year as a visiting professor in the Division of Marine Hydrodynamics at the Norwegian Institute of Technology in Trondheim. He started his leave by sailing to Norway in his own boat.

Professor J. Daniel Nyhart spent the spring term on sabbatical as a member of the faculty of law and a visiting fellow of the Centre of International Studies at Cambridge University in England.

Professor Paul Xirouchakis was on leave of absence during the spring term to conduct research at Det norske Veritas, the Norwegian ship classification society, on the buckling behavior of offshore structures.

William A. Baker, lecturer and, for 18 years, curator of the Hart Nautical Museaum, retired on July 1, 1981. His colleagues and friends were saddened by his sudden death in September.

Visiting faculty and staff this past year are listed as follows:

Per Gabrielsen visited from Det norske Veritas to collaborate with Professor Justin Kerwin on research on propeller hydrodynamics.

Professor Rui-Hua Hu, an associate professor in the Department of Building Engineering at Tongji University in the People's Republic of China, studied the design and construction of offshore platforms during the past year, in collaboration with Professor de Oliveira.

Akihiko Imakita, research engineer with Mitsui Engineering and Shipbuilding Company of Japan, conducted research on structural strength with Professor Masubuchi.

Michio Kuroda, research engineer at Toyo Engineering Corporation of Japan, studied ice fracture mechanics with Professor Xirouchakis.

Activities and Awards

Professor Martin A. Abkowitz was a major participant in the "Workshop for Development of an International Joint Ship Maneuvering Program."

Professor Arthur B. Baggeroer was an invited participant at the Digital Signal Processing Conference sponsored by the National Science Foundation (US) and Center for National Research (Italy). He was also a guest speaker at the NATO-SACLANT Center's Conference on Arctic Acoustics at LaSpezia, Italy.

Professor Chryssostomidis is cochairman of the Conference on Behavior of Offshore Structures (BOSS '82) to be held at MIT in August 1982.

Professor Ernst Frankel presented short courses on port planning in Singapore and Mexico and two seminar series on shipbuilding technology in Korea. He was an advisor to the World Bank on evaluation of transport projects. He is the US alternate representative on the Technical Committee of the Permanent International Association of Navigation Congresses and a member of the Naval Surface Ship Requirements Task Group of the Congressional Budget Office. He has had two books published this year, *Regulations and Policies of American Shipping* and *Management and Operations of American Shipping.*

Professor Henry S. Marcus gave a course on port development in Brazil. He is a member of the National Advisory Committee on Oceans and Atmospheres Subcommittee on Marine Transportation and the National Academy of Science's Maritime Transportation Research Board.

Professor Masubuchi is vice president of the Japan Society of Boston, vice chairman of Commission X of the International Institute of Welding, and chairman of the Organizing Committee for the Institute's 1984 annual assembly.

Professor Jerome Milgram is a member of the Canadian-Norwegian-American working group studying offshore blowout effects and determining methods of capturing the oil from these blowouts.

Professor Newman presented lectures at the University of Oslo Det norske Veritas (in Oslo), Helsinki University of Technology, and the University of Hamburg, as well as at the Norwegian Institute of Technology, where he spent his sabbatical.

Professor de Oliveira was appointed The Harold and Esther E. Edgerton Professor of Ocean Engineering for 1981-83.

Professor Harilaos Psaraftis presented papers on oil-spill clean-up at the International Federation of Operations Research Societies (IFORS-81) Congress in Hamburg and at the International Symposium IXTOC-1 in Mexico City. He was also an invited panelist at the Sixth Conference of the Greek Management Association in Athens.

Professor Sclavounos presented a paper at the third International Conference on Numerical Ship Hydrodynamics in Paris.

Professor Michael S. Tiantafyllou was selected as the 1982-84 Henry L. Doherty Professor of Ocean Utilization. He will work on the development of an underwater, unmanned tethered vehicle that will operate in ocean depths of up to 13,000 feet.

Professor J. Kim Vandiver is a member of the National Research Council Committee on Ocean Thermal Energy Conversion.

RESEARCH

Several research projects during the past year were funded by the offshore oil industry. One such project involved a series of field experiements at Castine, ME, under the direction of Professor Vandiver. Vibration repsonse and drag force on horizontal cylindrical cables exposed to tidal flow were measured. The large tides in Maine allowed the experiments to be setup on a

dry sandbar and provided a convenient range of flow past the cylinder. The results of these experiments will be used in designing deepwater drilling and production systems.

Long, flexible, tensioned cylindrical members, such as risers, have always been an important element of the offshore systems used for oil and gas. The design of the subsystems requires the solution of the hydroelastic problem of the motion of a cylinder in a real fluid. In order to contribute toward the understanding of this important problem, an industry consortium was initiated by Professor Chryssostomidis to provide experimental information on the stresses of long flexible riser models subjected to top-end motion and current forces. The first phase of these experiments has been conducted and the results will be presented in BOSS '82. The experiments were conducted at the towing tank of the National Technical University of Athens. Initial funding was provided by the MIT Sea Grant Program. A parallel riser experimental program was conducted in the deep Norwegian Towing Tank under the sponsorship of Conoco, Inc.

Hyundai Heavy Industries, Ltd., a Korean shipbuilding company, is sponsoring a research program in basic ship design and offshore engineering, strategic planning and management systems, and industrial application of technological forecasting. Professors Abkowitz and Frankel will be conducting these studies.

The Office of Naval Research (ONR) has funded a "special-focus program" in ship hydrodynamics. The emphasis is on numerical fluid mechanics, with application to free surface flows, maneuvering, and propulsion. Faculty participants at present include Professors Robert Van Houten, Yeung, Sclavounos, and Kerwin. Professor Newman, on his return from sabbatical in September 1982, will act as co-principal investigator with Professor Kerwin. This special-focus program represents a major departure from the ONR past practice of funding smaller single-purpose projects. The program in the Department is the first to be initiated in the country and it is expected to be followed by several similar programs at other universities.

Professors Baggeroer and Dyer are the chief scientists on the large-scale FRAM experiment programs in the Arctic. They recently returned from a biennial expedition in which a central station, along with several satellite stations, was built on the ice at a latitude of about 85°N. The propagation of acoustic waves through the water, the ice, and in the seabed was accurately measured and then analyzed *in situ* with on-line computers. The original motivation for these ONR-sponsored experiments was the need for military information, but the increasing likelihood that major oil and gas reserves may be found in the Arctic areas is generating great interest among some of the large energy companies.

Hart Nautical Museum

The sudden death in September 1981 of former curator William A. Baker precluded the planned orderly transfer of the Museum managment and brought urgency to questions about the Museum's future. As a temporary measure, the Department arranged informally for the director of the MIT Museums and Historical Collections, Warren A. Seamans, to take over management of the Hart Nautical Museum. John W. Waterhouse, a graduate student in the Department, was hired part-time to handle reference inquiries; Mr. Waterhouse has an unusual combination of experience in ship design and knowledge of marine history, which qualified him well for this task.

The availability of the professional services of the MIT Museums staff has proven to be a great asset in the management of the Hart Museum. Several projects have been undertaken to catalogue books, models, drawings, and artwork in the collection, initiate conservation measures, and set up special exhibits. We plan to negotiate a long-term arrangement with the MIT Museums staff that will combine their professional capabilities with the interest and expertise of the Department faculty.

Several significant gifts were received during the past year, including a gift from Mrs. William A. Baker of some navigational instruments and a number of books written by her late husband.

T. FRANCIS OGILVIE

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 computer robotics and vision, expert systems, learning and commonsense reasoning, natural language understanding, and computer architecture.

Professor Patrick H. Winston, director of the Artificial Intelligence Laboratory, and Professor Marvin Minsky lead research efforts in learning. Dr. Robert C. Berwick studies learning in the context of natural language syntax acquisition. Professors Berthold K.P. Horn, Tomaso Poggio, and Shimon Ullman head efforts in computer vision. Dr. J. Michael Brady, Dr. John M. Hollerbach, Professor Gerald J. Sussman and Thomas F. Knight work on the problems of integrated circuit design. Professor Randall Davis and Dr. Howard E. Shrobe work on expert systems that use functional and physical models. Dr. Charles Rich and Dr. Richard C. Waters explore the creation of intelligent programming environments. William D. Hillis and Mr. Knight explore the development of the connection memory machine, a special-purpose machine for concurrently manipulating knowledge stored in semantic nets. Professor Carl E. Hewitt studies distributed problem solving and parallel computation.

The Laboratory's 108 members include 12 faculty members, 5 academic staff, 38 research and support staff, and 53 graduate students active in research activities funded by the Defense Advanced Research Projects Agency, the Office of Naval Research, the Air Force Office of Sponsored Research, the National Science Foundation, Martin Marietta Corporation, and Digital Equipment Corporation.

Robotics and Vision

Professor Lozano-Perez, Dr. Rodney A. Brooks, and Dr. Matthew T. Mason, in collaboration with Dr. Russell H. Taylor of IBM, are designing a software system for automatic synthesis of robot programs from high-level task specifications. The system incorporates results in reasoning about space and object interaction.

Professor Lozano-Perez and Dr. Brooks extended previous results on obstacle avoidance to deal with paths requiring nearly continuous rotations. Dr. Brooks developed an efficient obstacle avoidance algorithm for the special case of convex objects. Dr. Brooks also proposed a method for checking and modifying robot plans to ensure that they will work, given mechanical errors in placement and orientation of objects. The method can be extended to the generation of the robot plans. Dr. Mason developed a theory of the behavior of objects moving under friction. The theory has led to powerful methods for accurately positioning objects without the use of sensory feedback.

Dr. Hollerbach, Mr. Hillis, and John A. Purbrick continued to develop high-resolution touch sensors, with emphasis on the use of new, more rugged materials. Dr. Hollerbach also implemented a new controller for a three degree-of-freedom tendon-driven shoulder which he designed. The controller, based on a model of muscle behavior, achieves human-like control of manipulator stiffness. Dr. Hollerbach and Tamar Flash studied the interaction forces during human reach movements. Information collected from arm movements is used to compute various contributions to the torques. They find evidence that humans use trajectory-formation strategies that simplify computation.

Professor Haruhiko Asada completed the design of a direct-drive manipulator. This innovative electromechanical manipulator uses no gears in its construction, which makes it very accurate and fast and, hence, ideal for assembly tasks. Professor Warren Seering and his students are investigating novel actuation methods with the goal of producing very fast and inexpensive actuators for manipulators.

Dr. Brady developed a new representation for visual contours based on local symmetry. Dr. Brady and his associates have implemented a software system for processing an image to detect object contours, obtain a representation of the contours, and use the representation to choose where the object should be grasped. This work is aimed at constructing a system that can pick an object out of a bin of similar objects.

In other vision-related work in robotics, Professor Horn and his staff study 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.

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. Anna R. Bruss 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 determined when the images captured by scanning electron microscopes determine surface shape uniquely. Professor Horn and Brian G. Schunck continued to investigate the use of the image-irradiance equation in determining the instantaneous velocity field which is generated on the image plane by movement in a textured environment. One important application is in navigation, where it is desirable to determine camera motion from noisy image sequences.

Another application of the image irradiance equation is in the interpretation of multiple images obtained using differing lighting conditions. William M. Silver implemented a multiple-image method to determine the orientation of each patch on the surface of an object. Philippe Brou is now using this kind of information to determine the identity of an object and its attitude in space.

In another effort, Professor Poggio, Dr. H. Keith Nishihara, and Dr. Kenneth Nielson developed a theory of spatio-temporal interpolation extending the classical sampling theorem. Work continues on developing efficient algorithms to process time-varying imagery that maintain high spatiotemporal resolution and avoid motion smear. The analysis of time-varying imagery is an important focus of research, since any visual processor with human-like performance must be capable of processing moving objects.

The measurement of the optical flow--the field of velocities in the image--is another important visual task. In collaboration with W. Reichardt and H. Bulthoff of the Max-Planck Institut fur Kybernetik in Tubingen, West Germany, Professor Poggio devised a model that uses intensity information in simple visual systems to compute directional motion and detect discontinuities in the optical flow. Professor Ullman and Ellen C. Hildreth investigate the computation of the optical flow by measuring velocity along contours in the image.

The Marr-Poggio theory of human stereo vision continued to represent a major focus of research. The understanding of stereopsis and its implementation in a real-time stereo machine with human-like performance has important applications, especially in robotics. Furthermore, stereopsis seems to require computations, such as edge detection, that are basic to many other visual tasks. Dr. Nishihara and Noble G. Larson have developed special hardware for doing some of these computations in real time. Professor Poggio and Dr. Nielsen compared the abilities of various stereo algorithms developed by Dr. W. Eric L. Grimson, Dr. Nishihara, Professor Poggio, and Michael Kaas.

Dr. Grimson developed algorithms for deriving a representation of a smooth surface given the incomplete sort of information that stereopsis provides. Professor Ullman and Demetri Terzopoulos explore the use of multigrid algorithms for efficient surface interpolation and other computations.

Professor Ullman also investigated the computations employed by the visual system in the perception of properties and relations such as closure, insideness, and connectedness. Understanding these computations is a step toward the development of a visual processor for object recognition.

Finally, Professor Poggio proposed a new theoretical approach to the computational mechanisms used by the brain to process information, which he calls the "biophysics of information processing." Using an extension of cable theory to describe nonlinear interactions, Professor Poggio has shown that a single dendritic tree may perform hundreds of independent analog operations on its inputs. The theory suggests that specific branching patterns reflect the information processing performed

by the neuron. A dendritic tree is then close to the ultimate in microelectronics, with patches of membranes representing the fundamental units for elementary computations.

Overall, the Laboratory has expanded its work in robotics considerably. One facet of the enlarged robotics effort has been to host prominent researchers in robotics for visits ranging from six months to a year. Another facet is to organize and hold intensive three-day workshops on topics in robotics such as the design of dexterous grippers and high-level programming languages. A third facet of the program is to encourage wider dissemination of results in robotics. As part of this effort, Dr. Brady and Professor Richard Paul of Purdue University founded *Robotics Research,* a new journal published by the MIT Press.

Expert Problem Solving

Professor Sussman and his associates have made considerable progress in their research into techniques and tools for very large scale integrated circuit (VLSI) design.

In one project, Gerald L. Roylance is working on a compiler for circuits. A circuit compiler is similar to a programming language compiler except that instead of compiling an abstract language to a concrete machine language, it compiles an abstract circuit design to a concrete one consisting of resistors, capacitors, and transistors. For example, an analog circuit design might use an abstract amplifier; the compiler might transform that amplifier into a transistor cascode circuit. In order to do this transformation, the circuit compiler must understand how the parts of the original circuit specification interact to constrain each other. These constraints are found by constraint propagation, a well-established artificial-intelligence technique. While analog circuit design is the domain of the Roylance compiler effort, the ideas about building circuits also apply to VLSI design, digital logic design, and other engineering domains such as numerical programming.

In another effort, Daniel Weise has developed and implemented a system for the interactive and incremental extraction of circuit schematics from hierarchically represented layouts of VLSI circuits. This system enables our design system to understand and answer questions about cricuits represented by layouts created using the design system.

Neil L. Mayle also has been working on simulation, investigating a method of incremental switch level simulation. A simulator of this sort allows the designer to simulate a cell when it is first designed. The information derived is memorized, thus saving the work of recomputing it during subsequent simulations.

In other VLSI-related work, James J. Cherry has been investigating circuit simulation algorithms suitable for implementation on parallel/pipelined architectures. Bruce E. Edwards has been working with Mr. Cherry on writing an electrical simulator.

Professor Davis's work has been focused in two main areas: model-based expert systems and the application of artificial intelligence to signal processing. He and his associates are building an expert system that uses knowledge about structure, function, design, and causality to do computer fault diagnosis. This system requires a knowledge base with a detailed domain model, distinguishing the system from previous expert systems, which are made from large collections of empirical associations.

Incorporating a detailed domain model represents an important advance in the art of expert systems construction. The next generation of systems must be armed with a more fundamental understanding of the devices they attempt to diagnose. While the current work is aimed at computer diagnosis because of its familiarity and the significance of the problem, the larger concern is that of reasoning about devices, understanding how they work and how they fail.

A second, smaller component of Professor Davis's expert systems work is a project on reasoning about geologic processes, inspired by earlier work on a program for analyzing certain types of measurements taken on oil wells. This project is aimed at developing a program that deals with causality and attempts to understand the underlying processes responsible for surface behavior.

Professor Davis also has collaborated with Professor Alan V. Oppenheim in exploring connections between artificial intelligence and digital signal processing, in the belief that techniques developed

in both areas can be modified and combined to produce improved signal interpretation and signal enhancement systems. This work has recently focused on problems of pitch detection and signal enhancement.

Drs. Rich and Waters study how expert programmers analyze, synthesize, modify, explain, verify, and document programs. One of their key observations is that expert programmers rely heavily on a large body of standard implementation methods and program forms. The heart of their research has therefore been to identify and codify these standard forms. For this purpose, they developed a language-independent formalism, called the plan calculus, in which these standard forms can be written down in a canonical and abstract way and used by an automatic programming system. Dr. Rich compiled an initial library of several hundred plans using this formalism.

Recognizing that the long-term goal of totally automatic programming is very far off, Drs. Rich and Waters are directing their research toward the immediate goal of developing an intelligent computer assistant for programmers, called the Programmer's Apprentice. As a first demonstration of how the Programmer's Apprentice can help a programmer, Dr. Waters implemented a new kind of program editor which understands how a program is built out of standard plans. With existing program editors, a single logical change to a program must often be achieved by many separate changes to different parts of the text. With the new editor, many such logical changes can be achieved by a single command. As their underlying theory develops further, Drs. Rich and Waters expect the capabilities of the Programmer's Apprentice to increase, with a corresponding reduction in the amount of work expert programmers are required to do.

Kenneth D. Forbus's work is on qualitative simulation of physical systems. The central idea of his theory is that an explicit representation of physical processes is central to commonsense physical reasoning. Processes such as flows and state changes - heating, boiling, moving, and breaking - form a major part of the physical phenomena that must be dealt with, so reasoning about when they occur, the changes they cause, and the ways they end is important for understanding physical reasoning. Mr. Forbus has developed a representation for reasoning about quantities called the quantity space. This representation is particularly good for dealing with the inequalities that mark state changes.

David A. McAllester has produced a reasoning utility package that is now in use in Mr. Forbus's project and many others. The package has programs for doing simple deductions, recording justifications, tracking down assumptions, and performing modifications as premises are changed.

Language and Learning

Dr. Berwick extended his model of language acquisition so that almost the entire core of English syntax can be learned by a computer program that examines simple English sentences. The extended model makes it possible to test the acquisition program on languages other than English. As a first step towards this goal, two experimental parsers were designed and implemented for languages other than English. One is based on earlier work done at the Laboratory, combined with recently proposed linguistic theories of German syntax. The aim was to confirm that the earlier work, based on English, could be extended to German. The other parser analyzes simple Japanese sentences.

Professor Winston's theory of reasoning by analogy consists of the following parts: an English understanding module, by Boris Katz, that converts prepared text into relations in a semantic network; a relation-exploiting hypothesizer that searches memory for precedents likely to be similar to a new given situation; a cause-dominated matcher that finds the best possible correspondences according to the causal framework determined by the situations themselves; an analogizing module that reaches conclusions about a given situation by using a remembered precedent; and a rule builder that constructs if-then rules.

During the past year, Professor Winston has improved the reliability of the constructed if-then. The key idea is to block if-then rules when contraindicated by information already in hand. The blocking mechanism involves censors of the sort suggested by Professor Minsky.

Censors are an important component of Professor Minsky's society of minds theory, in which intelligence emerges from the interaction of large societies of rather simple individual agents. Because each agent is relatively simple, communication between agents is 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.

Computing Concepts and Distributed Problem Solving

Our connection memory machine is a computer that performs fast, parallel searches through networks, a fundamental, rate-limiting step in many problem-solving programs. Led by Mr. Hillis, work on this machine is a major effort.

During the past year a prototype machine has been designed and a packaging scheme selected. Thus we are almost ready to begin the implementation of prototype hardware. Because the design requires parts to be duplicated in great numbers, yield, testing, packaging, and reliability are receiving careful attention. The large scale of the project forces the development of new methodologies and design tools.

Alan Bawden has written a simulator which simulates the hardwired instruction set of the connection memory machine. This simulator will be used to write and debug programs for use in testing the physical machine. Using the simulator, Mr. Bawden is now writing a truth-maintenance system.

For more advanced applications, such as working with semantic network databases, we have designed and implemented a prototype high-level language called Cmsl. To the Cmsl programmer, all data appear as a graph of named vertices connected by edges. In reality, the graph is represented as structures of connection machine cells. Some Cmsl operations correspond almost directly to a single connection machine instruction. Others involve complex patterns of messages passed between cells.

Another approach to creating parallel systems is that of Professor Hewitt and his associates. They have developed actor theory, a rigorous abstract theory of parallel systems, that may provide a foundation for the construction and analysis of highly parallel problem-solving systems. Several important components have been developed including the Act 1 subsystem to model specialized communicating agents, the Omega subsystem for parallel semantic taxonomic relational networks, and the Sprites subsystem to model the communications activities involved in processing general goals and assertions.

Professor Hewitt is now working on a computer architecture, called the Apiary, to implement actor systems efficiently and to test the basic concepts.

Finally, Professor Sussman and his associates have completed the design of the SCHEME-81 chip, a VLSI device for running SCHEME, a dialect of the LISP programming language. In addition to testing the limits of our automated design aides, the SCHEME-81 chip may be a step toward better LISP-oriented personal computers: preliminary estimates are that SCHEME-81 will interpret simple LISP programs about five times faster than our best current hardware. For large, complex programs, it will do even better.

A special-purpose silicon compiler, by Philip E. Agre, has been important to the development of SCHEME-81. Given a small program definition, Mr. Agre's compiler produces code specifying the layout of a SCHEME-81 bus-compatible chip to implement that function. The compiler uses traditional techniques and some novel heuristic methods to reason about the trade-offs involved in writing highly parallel microcode.

Also, Jonathan D. Taft has been working on building a small SCHEME computer for testing our chips. It uses a Motorola 68000 design module as a front-end processor for performing I/O, for user-level arithmetic, for character manipulation, and for console control and debugging the SCHEME system.

The Computing Environment

The Laboratory's computing resources were improved by the installation of a large 20/60 system, a VAX 11/780, and a VAX 11/750, all manufactured by the Digital Equipment Corporation. These

machines complement a variety of existing machines, including nearly two dozen LISP Machines, designed and built by us.

All of the machines, together with terminal concentrators, are linked together with an eight-megabit packet-oriented cable system known as the CHAOSNET. The cable system can support as many as 100 communicating computers before reaching intolerable performance deterioration.

PATRICK H. WINSTON

Center for Advanced Engineering Study

The rapid pace of technological advance and accelerated international competition have increased general interest in continuing education for engineers. The Center thus maintains four major programs:

- the Advanced Study Program -- under which engineers in professional practice or teaching come to the Center for a semester or a year of individualized study.

- the Self-Study Program -- containing 1,000 videotapes which bring technical information to the place of work.

- the Seminars and Conferences Program -- which develops short courses, workshops, and seminars which permit practicing engineers to study subjects intensively for short periods of time.

- a Research and Development Program -- which seeks better information about the needs of practicing engineers and new techniques for meeting them.

The Center also conducts a Department of Energy-sponsored research program in complex thermoeconomics systems under the direction of Professors Myron Tribus and Yehia El-Sayed. These methods are now being applied to several problems of industrial interest.

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 68 Fellows from 15 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 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 certificated 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 men from 15 countries are attending the course.

Self-Study Program

MIT video courses reached over 35,000 practicing engineers, scientists, and technical managers during the past year. Five thousand new participants are being added each year. The program is continuing to work on the objective of providing video-based continuing education at a distance.

A major development was the production of the Deming Videotapes and landmark textbook: *Quality, Productivity and Competitive Position*. W. Edwards Deming is the internationally renowned statistical consultant whose work revolutionized industry in Japan. Dr. Deming's management methods are now being implemented by a significant number of US companies.

Plans were made to produce Introduction to Analog and Digital Signal Processing with Professor Alan V. Oppenheim. Professor Oppenheim's graduate-level video course, Digital Signal Processing, produced in 1975, has reached more than 25,000 practicing engineers.

Many additional subjects are being considered for development as video courses. Among these are: Advanced Digital Signal Processing Applications, Advanced Microcomputer Applications, Laser Technology, Microelectronics, Instrumentation, Management of Technology, Engineering Design, Composite Materials, Heat Transfer, and Polymer Chemistry.

The Conference, Seminar, and Short Course Program

The Conference and Seminar 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 the Engineering and Academic councils 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 1981-82 programs included: "Managing Productivity: Analysis Techniques for Improved Organizational Performance" sponsored by the Laboratory for Manufacturing and Productivity; "Advances in Nuclear Systems Thermal Analysis" sponsored by the Department of Nuclear Engineering; "Advances in Finite Element Methods in Structural Mechanics III" sponsored by the School of Engineering; "Microprocessor Applications: Software and Hardware Techniques" sponsored by the Center for Advanced Engineering Study; "Third International Conference on the Behavior of Offshore Structures" sponsored by the Department of Civil Engineering; "Transportation Systems Management and Analysis" sponsored by the Center for Transportation Studies (CTS); "Forecasting Transportation Demand" sponsored by CTS; "Railroad Operations, Planning and Management" sponsored by CTS; "Microcomputers in Transportation' sponsored by CTS; "Regionalism in International Air Transportation" sponsored by the Flight Transportation Laboratory; "Rebuilding America: Challenge to the Construction Industry" sponsored by the Center for Policy Alternatives.

During 1981-82, more than 25 foreign countries and 45 states in the US were represented at continuing education offerings from the Seminar Office. The 500 percent increase in programs during the past 24 months is an indication of the interest in continuing education meetings. Therefore, the number of program offerings is certain to increase substantially during 1983.

Research and Development

During the year Project PROCEED (Program for Continuing Engineering Education), originated several years ago by Professor Lawrence B. Evans of the Department of Chemical Engineering, was brought to a close. It had been sponsored by Control Data Corporation. In the last year the system was made operational and the learning modules were produced by MIT Press, *Industrial Energy Conservation Manuals* (Vols. 1-17). The manuals represented the largest publication task undertaken by the MIT Press.

The Center continues to search for a sponsor willing to take the computer-based adaptive reference system to the marketplace, and a new director for the R&D program is being sought.

MYRON TRIBUS

Center for Policy Alternatives

In 1972, the president of MIT, who was then Jerome Wiesner, saw the need for a policy group at MIT to examine technology and engineering problems and their interaction with social issues. This past year the Center for Policy Alternatives (CPA) celebrated its 10th anniversary. On this occasion, Dean Gerald L. Wilson created a board to advise the Dean of the School of Engineering and the director of CPA on CPA's teaching and research.

The newly formed advisory board includes representatives from universities, industry, government, and international organizations. Dr. Harvey Brooks, Benjamin Pierce Professor of Technology and Public Policy at Harvard, is chairman of the advisory board. Other university representatives are Dr. Eula Bingham of the University of Cincinnati, Professor Irving Bluestone of Wayne State University, Professor Anne Carter of Brandeis, Dr. Joel Fleishman of Duke University, and Dr. Paul Streeten of Boston University.

Representatives from industry are Alexander d'Arbeloff, president of Teradyne, Inc.; Charles F. Barber, chairman of the board of ASARCO, Inc.; Dr. Donald Frey, chairman of the board and chief executive officer of Bell& Howell Company; John C. Haas, Vice chairman of the Rohm & Haas Company; Milton Stewart, editor of *Inc.* Magazine; Dr. Howard Turner, chairman of the executive board of Turner Construction Company; and Dr. Thomas Vanderslice, president of General Telephone and Electronics.

CPA Board members who hold government office are the Honorable Don Fuqua, chairman of the House Committee on Science and Technology; and Dr. David Pittle, commissioner of the Consumer Product Safety Commission. Other CPA Board members are Magdi R. Iskander of the World Bank; Dr. Joseph Short, executive director of Oxfam America; and former US Senator Adlai E. Stevenson III.

Following the first meeting of the advisory board, Mr. Stevenson delivered a talk on "Technology and Industrial Development: A Senator's View."

RESEARCH

Innovation and the Process of Industrial Development

As part of a project sponsored by the National Swedish Board for Technical Development, CPA has just completed a study of the contribution made by new technology-based firms to industrial innovation in Sweden. The study, led by Professor James Utterback and Dr. Andrew Martin, analyzed the characteristics of 60 technology-based firms started between 1965 and 1975. Such factors as founder's background, technology sources, products, markets, financial sources, and governmental support were related to the firms' performance. The entrepreneurial phenomenon in Sweden was found to be a significant source of jobs and products that compete strongly on the world market. Larger and older firms proved to be an important source of technology, people, and especially early markets for the young firms that were studied.

Two other parts of the project were a pilot study of technical communications among research and industrial organizations, under the direction of Professor Thomas J. Allen of the Sloan School; and a study of the role of the Board for Technical Development in the innovation process in Sweden, conducted by Dr. Martin. Dr. Martin is working with the board to incorporate the results of the study in its long-term planning process.

Looking at the development of the automotive industry, Professor Utterback and Visiting Professor Burton Klein studied the applicability of dynamic competition. The theory of dynamic competition holds that a firm can assure its predictability in the large only by being unpredictable in the small, i.e., by a willingness to make or to borrow new discoveries. This work was funded by the German Marshall Fund.

Professor Utterback conducted a follow-up study analyzing the potential commercial and foreign trade impacts of the Sea Grant Program. In the earlier research performed in 1976, 77 projects were examined with an estimate of their sales profits and impact on balance of payments for 1980. The new project reevaluated and validated those estimates; the statistical results will be available next year.

CPA's project on Industrial Technology Development in Portugal continued through the year. It is a collaborative undertaking between CPA and the National Laboratory of Engineering and Industrial Technology (LNETI) of the Ministry of Energy and Industry in Portugal. Financial support for the study is provided by the government of Portugal through a World Bank loan. The project is led by Principal Investigator K. Nagaraja Rao and is studying the technological level of Portuguese industry. Specifically, researchers are examining the capacity of the scientific and technological infrastructure to support modernization of existing industries so that Portugal can develop and commercialize new products and processes. Such activities would improve the competitiveness of Portuguese industry as it enters the European Common Market in the mid-1980s. Fieldwork has been completed with some 100 Portuguese firms and many governmental and nongovernmental agencies. Techno-economic analysis of both the traditional and emerging sectors in Portugal has also been undertaken to develop some scenarios of technological development. The findings of these studies are now being synthesized into several reports, which will provide inputs to a Mid-Term Technological Developmental Plan of the Portuguese government.

Dr. Christopher T. Hill conducted a study of the indicators used by the National Science Foundation (NSF) to evaluate US science and technology enterprises. During Phase I, researchers developed five new indicators to assess the state of technological innovation. These indicators will be tested in Phase II of the project.

Industrial Factors Influencing the Health and Safety of Workers, Consumers, and the General Public

CPA recently completed a year-long study of the productivity response of industry to occupational asbestos regulation. The retrospective study documented the technological and productivity changes that occurred in 40 firms in response to asbestos regulation. The impacts of regulation on production were traced to operating costs, capital expenditures, medical monitoring, hygiene, product substitution, and product elimination. Productivity impacts were shown in relation to the costs of production at the plant and in relation to the total value-added costs to final consumption. Performed for the Office of the Assistant Secretary for Policy Research of the US Department of Labor, the project was directed by Dr. W. Curtiss Priest; Professor Nicholas A. Ashford served as principal investigator. Results of the project appeared in the MIT Industrial Liaison Program's *Reports on Research* and were presented at two national conferences in Washington.

Another CPA study of regulation and technological change focuses on the pharmaceutical industry and is sponsored by the NSF. Phase II of the project began last year and is headed by Principal Investigator Professor Ashford and Project Manager Dr. Dale Hattis. The project team 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 (FDA) 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.

Recently there has been a growing interest in the use of cost/benefit analysis in environmental policy to formulate better approaches to estimating regulatory benefits. In an 18-month study funded by a consortium of US regulatory agencies through the Environmental Protection Agency (EPA), the research emphasis was on expanding the range of methodologies and considerations beyond those commonly used in benefits analysis. The project team, Professor Ashford and Drs. Hattis, Hill, and Priest, examined the implications of different health, accident, and environmental damage models for benefits analysis. Considerable attention was 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. Members of the research team also considered the ancillary benefits of regulation, which include effects that stimulate technology.

Dr. Hattis and graduate student Nancy Gorelick conducted a study sponsored by the Occupational Safety and Health Administration (OSHA) to demonstrate how control of toxic materials may be accomplished without legal intervention by Federal agencies. The metal-cleaning process and dry-cleaning industry were chosen as case studies because their economic and political structure (many small, dispersed production units) make mandatory controls on users relatively inefficient They found, however, that conditions do exist for voluntary exposure controls. For example, trade associations, labor unions, and insurance companies can alert firms of the hazards and opportunities for control.

In other work for OSHA, Dr. Hattis updated a 1977 study that developed a model for testing the level of lead in the blood of workers. This year he used new data to test the predictions of that model and develop alternative models. These newer models can be used in conjunction with the earlier model to make plausible predictions of lead levels under changing exposure conditions.

CPA recently completed its first-year effort of a three-year cooperative agreement with the Office of Toxic Substances at EPA. This project, led by Principal Investigator Ashford, is designing strategies for the identification, testing, and control of toxic substances. The research has developed a methodology for anticipating risks from new chemical technology, investigated the conflicts of goals between public and private interests in trade secret data, and suggested measures for voluntary control of toxic substances.

For the past three years CPA has been studying regulation and the automobile industry. In September, researchers under the direction of Principal Investigator Ashford and Project Manager George R. Heaton, Jr., finished a project for the EPA. The final phase of this study was a comparative analysis of US and foreign regulations, an analysis of the development of emissions control technology since the 1950s, and an assessment of alternatives to current experience. As in other studies, researchers found that the use of cost/benefit analysis may have more drawbacks than advantages.

Lastly Dr. Hill conducted a critical assessment of the use of engineering cost analysis for projecting costs of compliance with environmental standards. Since environmental regulations tend to cause firms to change their technologies so as to control the risks they pose, what is needed is a dynamic model which can account for change.

Technology Assessment

Under the direction of Principal Investigator Robert T. Lund, the Advanced Technology and Industrial Productivity (ATIP) Program's case study of the introduction of automated machine systems in a tractor components manufacturing operation at Caterpillar Tractor Company was completed in November 1981. The ATIP Program is a cooperative venture between MIT/CPA and a group of participating firms to explore the impacts of computer-based automation on manufacturing organizations and their employees, products, and operating results. Participating firms provide both funding and research sites for the program. Research centered on the firm's decision to automate specific processes for the manufacture of a major new product line; its approach to selecting vendors and the type of relationship it developed with them; and its experience with the choice, design, installation, and start-up of the new manufacturing system.

Three additional projects under the ATIP umbrella have been started this past year with support from Eastman Kodak. These projects explore issues related to the implementation of computer-based manufacturing technologies: the manning of robots, the impact of automation on manufacturing production occupations, and unemployment compensation.

In the remanufacturing project sponsored by the US Department of Energy (DOE), CPA staff under the direction of Mr. Lund have been working on an engineering feasibility study of the remanufacturing of chain saws. Remanufacturing is an assembly-line repair and refurbishing process in which worn-out, mass-produced durable products are rebuilt to perform equal to or better than the original new product. CPA's research is the first comprehensive study of

remanufacturing in the US. In addition to investigating the technical feasibility and requirements of remanufacturing chain saws, the project team is studying the economic benefits, energy conservation implications, and legal and regulatory constraints involved in remanufacturing this product. One purpose of the engineering feasibility study is to establish a model for use by private investors who want to consider remanufacturing mass-produced products.

Working with the US Army, Mr. Lund has been examining the possibility of using product-life-forecasting techniques to establish maintenance and replacement routines for Army weapons systems.

With Professor Ithiel Pool, Dr. Marvin A. Sirbu conducted a study of alternative tariff policies for telecommunications services, and examined the implications of different tariff policies under different circumstances. They concluded that rates for local and long-distance services fail to reflect true cost trends, and that some system of compensation from the long distance to the local service must be provided or there will be serious deterioration of the latter.

At the request of Citicorp., Dr. Sirbu investigated the Digital Termination System (DTS), a high-speed digital communication system that is one alternative to the local telephone loop. His study examined the technology, cost structure, and regulatory/policy issues of the DTS.

Dr. Sirbu continued CPA's research into office automation during the past year. He and Dr. Michael Brill of BOSTI in Buffalo, NY, developed an instrument for assessing managers' needs for advanced support systems.

The Role of Technology in National Development

Dr. Nancy S. Dorfman conducted a study of high-technology industries in Massachusetts during the late 1970s. She investigated the forces that caused the boom and studied the role of relatively new firms in the high-technology market and the reasons for their success. A summary of her study appeared in CPA's *Policy Choices*.

The Office of Technology Assessment (OTA) of the US Congress is contemplating a major study of how technology and technological innovation affect the location of industry in the US. In a preliminary study funded by OTA, Dr. Hill and Dr. Rao examined the issue to review major areas of consensus and suggest avenues of further study to OTA.

CPA has an ongoing program of modeling and analysis of the supply and demand for engineers and other technical labor. Our past work has principally been concerned with the impact of economic factors on technical labor market employment levels and salaries, and has focused critically on adjustments of employers' anticipated hiring levels (demand) as well as adjustments in labor participation rates (supply) that result from changing economic incentives. Our current work in this area, directed by Dr. John Hansen, is geared toward the development of a forecasting model that can be used to simulate various policy responses to the recent apparent shortage of engineers. This research focuses both on the national market for engineers as well as regional market conditions in New England and Massachusetts.

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 degree 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 their choice. Since the program's founding in 1976 by Professor J. Herbert Hollomon and MIT's former president Wiesner, many TPP students have received policy analysis training at CPA.

During the past academic year CPA staff members offered subjects in the new Joint Program in the Management of Technology, sponsored by the Sloan School of Management and the School of

Engineering. Professor Hollomon, Mr. Heaton, Dr. Hill, and Professor Ashford taught Government and the Management of Technology. Professor Utterback and Professor Edward Roberts taught Technology Planning, and Professor Utterback and others taught Manufacturing/Technology Interface.

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 18 theses were completed under the direction of CPA staff members.

INFORMATION DISSEMINATION

During the past year, CPA continued its publication of *Policy Choices: A Review Discussing Technology, Engineering, and Social Policy*. *Policy Choices* this year had a lead article by Dr. Paul Gray on "Engineering Education at the Crossroads" and another on the research of Dr. Evelyn Fox Keller, "Educating Women Engineers." *Policy Choices* continues to increase the circulation of CPA reports, and draw favorable reception.

During the fall semester, a seminar series was held in conjunction with the course on Government and Management of Technology. The series, "Perspectives on Technology Policy in the 1980s," featured, among other, President, Emeritus, Wiesner and Provost Francis E. Low.

CPA Bibliographic Management System (BMS), a computer-based storage and retrieval system designed by Dr. Priest and based on the FOCUS database management system, is now in its third major version. Interest in this powerful research tool, which organizes and searches bibliographic material and generates bibliographies, continues to grow within CPA and the larger MIT community, as well as outside of the Institute. BMS is now being used by MIT's Technology Adaptation Program and by the Aga Khan Program for Islamic Architecture. BMS software is available for license from MIT, and current outside users include Brown University and the Insurance Company of North America.

In conjunction with the Center for Advanced Engineering Studies, CPA sponsored a two-day conference of remanufacturers at MIT in August. Keynote speaker US Senator Paul Tsongas addressed the conference on the need for remanufacturers to organize and lobby for preferential Federal legislation to aid and protect manufacturing practices that conserve valuable energy and materials resources. Another conference has been tentatively scheduled for December 1982.

Public Service

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.

Professor Ashford testified in October 1981 before the House Subcommittee on Health and the Environment on the need to retain health-based standards under the Clean Air Act. He has also worked actively with the Senate Committee on the Judiciary on the Regulatory Reform Act of 1982. Professor 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 EPA. He was recently elected a Fellow of the American Association for the Advancement of Science. Professor Ashford was a member-at-large of the American Public Health Association's Program Planning Committee for its 1981 meeting, and, during the past year served as annual 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. He also headed a NSF Panel on the use of scientific and technical information in regulatory decisions.

Professor Utterback testified before the Senate Committee on the Small Business Innovation Research Act on July 16.

In September, Dr. Hansen testified before the Federal Regulatory Energy Commission on competition in wholesale electric power markets.

Mr. Lund was an invited advisor to the United Nations Industrial Development Organization in Mexico City for a week in June. He advised them on computer applications in Latin American countries.

Dr. Martin testified on October 20 before the Joint Economic Committee on income policies.

Dr. Rao presented two papers at the International Seminar on the Modernization of Industry in Hunan, China in November.

Dr. Hill was elected Secretary-Treasurer of the Engineering and Public Policy Division of the American Society for Engineering Education (ASEE) and addressed the ASEE annual meeting on "Engineering and New Technology: Meeting Regulatory Goals While Improving Productivity."

Staff Publications

CPA staff members contributed to many books, journals, and CPA reports during the past year. Some of these publications included the following:

Ashford, Nicholas A., "The Conflict Over Workplace Inspections," in *Legal and Ethical Dilemmas in Occupational Health*, Ann Arbor, MI, Ann Arbor Science Publishers, 1982, pp. 141-147. "Cost-Benefit Analysis: Can Balance Be Achieved?" in *Occupational Health and Safety*, May 1982, pp. 10-12, 42-45. "Regulatory Reform and the Need to Retain Health-Based Standards Under the Clean Air Act," testimony presented before the House Subcommittee on Health and the Environment, Committee on Energy and Commerce, October 14, 1981. "Regulatory Responses to Carcinogens, Mutagens, and Teratogens," pp. 34-43 in *Quantitative Risk in Standards Setting*, Proceedings of the 16th annual meeting of the National Council on Radiation Protection and Measurements, April 2-3, 1980. National Council on Radiation Protection and Measurements, 1981.

Basberg, Bjorn L., "Patents, Innovations and Technological Development in Norwegian Whaling, 1880-1968, " in *World Patent Information*, vol. 3, no. 1, 1981, pp. 19-22.

Dorfman, Nancy S., "Gasoline Distribution Policies in a Shortage: Welfare Impacts on Rich and Poor," in *Public Policy*, vol. 29, no. 4, fall 1981, pp. 473-505.

Hattis, Dale, Robert Goble, and Nicholas A. Ashford, "Airborne Lead: A Clearcut Case of Differential Protection," in *Environment*, vol. 24, no. 1, January/February 1982, pp. 14-20, 33-42.

Hattis, Dale, "Needs for Public Health Intervention and Needs for New Research on Vinyl Halides and Their Polymers: A Public Policy Perspective," in *Environmental Health Perspectives*, October 1981, pp. 227-231.

Heaton, George R., Jr., Marcia Allar, and Peter L. Maier, "The Uses of Regulatory Evidence in Tort Actions: Automobiles, Consumer Products, and Occupational Safety and Health," in *Journal of Products Liability*, vol. 4, nos. 3 & 4, fall 1981, pp. 231-253.

Hill, Christopher T., Richard A. Andrews, Nicholas A. Ashford, Richard L. Frenkel, George R. Heaton, Jr., Clifford S. Mitchell, and W. Curtiss Priest, "Policies to Address the Impacts of the Toxic Substances Control Act on Technological Innovation." Paper presented at the Second World Congress of Chemical Engineering, IX Interamerican Congress of Chemical Engineering, Montreal, Canada, October 4-9, 1981.

Martin, Andrew, "Incomes Policy Versus Organizational Cohesion: The Functions of Central Wage Negotiations in Sweden," in *Stato e Mercato*, 1, 2, September 1981.

Priest, W. Curtiss, "Cite-Reading," MIT *IPS Academic and Research Computing Services Newsletter (The Bulletin)*, issue 187, January/February 1982, pp. 28-29. "Regulation and Industrial Response: The Case of the Asbestos Industry," presentation at symposium on Government Regulation: Trends and Prospects, sponsored by the Industrial Liaison Program at MIT, November 18-19, 1981.

Priest, W. Curtiss, and Sohail Bengali, "Impact of OSHA Asbestos Regulation on Productivity in the Asbestos Industry," presentation at the Allied Social Science Association's 1981 convention, the Society of Government Economists, Washington, DC, December 28-30, 1981.

Rao, K. Nagaraja, "Desenvolvimento Technologico e de Organizacao (Technological Development and Organization: Summary Findings from Interviews with Portuguese Firms)," pp. 137-157 in *Proceedings of the Colloquium C4, Commission for the Study of the Electromechanical Sector,* held at the Portuguese Industrial Association, Lisbon, March 10-12, 1982. "Transfer of Technology and Promotion of Foreign Investment," prepared for and presented at the Changsha, Hunan, People's Republic of China seminar on "Modernization of Industry Related to Agriculture in Hunan -- A Sharing of Chinese and International Experience," November 4-14, 1981, sponsored by the Beijing Institute of Agriculture Mechanization in Changsha, Hunan. (A follow-up summary paper entitled, "Report of the Working Group on Technology Transfer," November 18, 1981.)

Rao, K. Nagaraja, and Joel Novek, "Canada and the United States: A Positive-Sum Game in Industrial Innovation?" paper presented at the Conference on US/Canadian Economic Relations: Where Are They Going?, sponsored by the Faculty of Administrative Sciences, York University, and the International Economics Program of the Institute for Research on Public Policy, Ottawa, Canada, November 21-31, 1981.

Rao, K. Nagaraja, R.F. Baddour, and Christopher T. Hill, "Strategic Aspects of Chemical Industry Development in the Rapidly Industrializing Nations." Paper presented at the Second World Congress of Chemical Engineering, IX Interamerican Congress of Chemical Engineering, Montreal, Canada, October 4-9, 1981.

Sirbu, Marvin A., Jr., "The Innovation Process in Telecommunications," pp. 184-198 in *Telecommunications and Productivity,* edited by Mitchell L. Moss, Addison-Wesley Publishing Company, 1981, Reading, MA.

Utterback, James M., "The Creation and Use of Technology in Industry." Invited paper presented at the New Orleans meeting of the American Physical Society, November 23-25, 1981. "The Innovative Process: Evolution vs. Revolution," pp. 59-78 in *Proceedings of a Symposium for Senior Executives,* held November 12-13, 1981, Cambridge, MA, MIT Industrial Liaison Program. "Productivity and Technological Innovation," paper presented at the MIT Symposium on Productivity Management, March 16-17, 1982.

FACULTY, STAFF, AND STUDENTS

CPA's permanent staff includes 10 research staff, three faculty, seven temporary research specialists, three administrative staff, and 10 support staff. In addition to the permanent staff, 40 students and seven visiting researchers worked on CPA research the past year.

Faculty and Staff Changes

Dr. Dorfman, an economist who previously worked at the Center for Transportation Studies, joined CPA in the summer. She has completed the first phase of a study of high-technology industries in Massachusetts. Dr. Hansen, also an economist, joined CPA in September. He formerly worked as a senior research associate with Charles River Associates. This year, he has assisted Drs. Rao and Hill on their research projects. Judith Sobel and James McCarthy joined CPA's administrative office, coming from ABT Associates and the Cairo University/MIT Technological Planning Program.

Visiting Research Staff

Dr. Burton Klein of the California Institute of Technology spent two months at CPA while writing a book on dynamic economics. Bjorn Basberg came to CPA from the Norwegian School of Economics and Business Administration. He studied problems connected with the use of patent statistics as indicators of innovation and technological change. Dr. Bo Carlsson from the Industrial Institute for Economic and Social Research in Stockholm has investigated international growth patterns with

CPA staff. Dr. Kee Young Kim, professor of Management at Yonsei University Graduate School of Business Administration, Seoul, Korea, spent the year with CPA analyzing the transfer of technology among less developed countries.

For the seventh year, two graduate students from the University of Konstanz in Germany participated in CPA research. Richard Arnold and Christian Egenhofer worked at CPA until late spring under the direction of Dr. Rao.

J. HERBERT HOLLOMON

Center for Transportation Studies

The Center for Transportation Studies (CTS) was established in 1973 to centralize and coordinate transportation-related activities at MIT. It provides a focal point for transportation education, facilitates transportation research, 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 works with 11 academic departments throughout the Institute. In addition to the director, it maintains a full-time research staff of six and an administrative staff of six, with approximately 50 affiliated faculty.

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 1981-82 were Professor Alan Altshuler (Head, Department of Political Science), Professor Ralph Gakenheimer (Urban Studies and Planning), Professor Thomas Magnanti (Sloan School of Management), Professor Steven Lerman (head, Transportation Systems Division, Civil Engineering), Professor Herbert Richardson (Head, Department of Mechanical Engineering), Professor Robert Simpson (director, Flight Transportation Laboratory, Aeronautics and Astronautics), Professor Nigel Wilson (chairman, Standing Faculty Committee for the Transportation Master's Program), and Professor Daniel Roos (director, CTS).

Graduate Program

The new interdepartmental master's program in transportation completed its third year with an enrollment of 37 students last fall, close to the expected long-term enrollment of 40-70 students. One of the objectives in creating the program was to make it both accessible and attractive to students with a wide range of backgrounds. In this respect, it has been very successful -- almost 50 percent of the graduates have undergraduate degrees in civil engineering, and the remainder come from a dozen different disciplines including business, planning, engineering, philosophy, English literature, and geology. This diversity is also reflected in the fact that one-third of our students entering the program have prior work experience in transportation including positions with carriers, different levels of government, and consulting firms. About one-half our students come from abroad, with the greatest concentration from Europe, the Middle East, Latin America, and Asia. This diversity of backgrounds has been an important element in the overall education of the students in the program -- they learn from each other as well as from the faculty and staff.

While enrolled in the program each student selects one of 12 areas of specialization. Half the students have elected to focus on urban or public transport with other common choices being freight and air transport. Thirty-eight students have graduated from the program in its first three years, with a majority of the graduates going to work directly for transport operators or transport planning agencies. The variety of positions taken by our graduates indicates that the program is educating students for a broad range of private sector and public sector jobs.

Curriculum development activities over the past year have focused on new subjects relating to the management of transport systems and to textbook writing. Two new subjects will be presented in the fall, one on transit management, the other on management of transport activities at the state and regional levels. Textbooks for two of the core subjects, Transportation Institutional Analysis and Policy, and Transportation Demand and Activity Analysis, should be completed within the next

year and development of a third book on Transport Networks is also under way. Textbook development is viewed as a top priority since it leads both to better education for our students, and to increased visibility and reputation of the MIT transportation program both in the US and abroad.

Senior Executives Program

A new continuing education program for senior executives in transportation organizations was initiated this year. The program is developed jointly with the Sloan School of Management and was strongly recommended by our Advisory Board. The first offering this summer will be a one-week program in Strategic Management to be taught by Professor Arnoldo C. Hax and Professor Magnanti of the Sloan School of Management and Professor Lerman of Civil Engineering. Drawing on research from a variety of disciplines -- management sciences, marketing, organization theory, information systems and control, industrial economics, and finance -- the course introduces the concepts of strategic management as well as a framework for designing and supporting a strategic plan within the specific context of transportation firms and institutions. This course will be repeated in future years and several companion courses will be developed.

Research Program

In spite of significant reductions in funding for transportation research by the US Federal government, the research program of the Center this past year increased to over $2 million. For the first time, research support from the US government was less than 50 percent of all the Center's research funding. An increasing amount of research support in being obtained from the private sector, foundations, and foreign governments. For example, the largest project in the Center, "The Future of the Automobile Program," is supported primarily by two private foundations, the German Marshall Program of the United States and the Lilly Endowment.

The Center has more than 30 active research projects involving faculty from eight academic departments. These projects are quite diverse, dealing with different transportation modes and a range of different problems. Rather than summarizing each of these projects, we will focus on transportation research in developing countries, an activity of growing interest within the Center.

Three-quarters of the world's population live in developing countries, and these lands are of increasing importance to the world economy. Transportation is one of the most basic and crucial needs of economic development in these countries, and the Center is involved in several research and educational programs investigating the interaction between transportation and the development process. Projects relating to urban transportation in Cairo, Egypt, and intercity transport in Egypt are under way in conjunction with the MIT Technology Adaptation Program. A one-week course on Transportation System Analysis, sponsored by the Center and the Industrial Liaison Program, was offered in Taiwan and attracted more than 100 students.

The most ambitious Center program with developing countries involves a cooperative relationship with the Brazilian Ministry of Transport. This program is now entering its third year and involves both research and educational activites. The scope of this program was significantly expanded over the past year, incorporating two research projects and a two-week intensive course on freight transport system performance presented in Brazil. The research projects include an examination of the nature of urban travel demand in Brazilian cities, and a study of non-capital intensive methods to improve freight transport performance in a Brazilian export corridor. The Brazilian program has expanded from a funding level of $150,000 in 1981 to over $300,000 in 1982. During the past year the Program has provided support for five faculty members, two staff members, and five students in two academic departments.

From the perspective of the Center's desire to build up expertise and experience relevant to developing countries, the Brazilian program provides an opportunity to work closely with one of the premiere transport planning and policy analysis agencies in the developing world, affording Center personnel the opportunity to deal with important transport problems that are relevant not only in Brazil but in other countries as well. The fact that the program is funded entirely by the Brazilian government helps to ensure that it deals with issues of practical relevance in one of the most technically advanced of the developing countries.

Center Endowment

During the past year, the Center received a gift of $550,000 from the United Parcel Service (UPS) Foundation. This is the fourth gift received from UPS. These gifts have produced an endowment fund to the Center in excess of $1 million and over $100,000 in grant support.

UPS Foundation endowment and grant funds have allowed the Center to enrich its educational and research opportunities in substantial ways and at the same time meet many important human needs. Next year for the first time, a UPS Foundation Fellowship will be given to a graduate student in transportation. UPS Foundation funds have been used extensively for curriculum development purposes. As a result of the generous gift received this year, the Center initiated a program of seed research grants to faculty and staff. Awards made this year include:

1) Development of a Database on Shippers -- for developing data collection procedures in assembling a database on shipper behavior and motivations for use in the development of more extensive information for analysis. (Daniel McFadden, professor of Economics; and Clifford Winston, assistant professor of Civil Engineering)

2) Dynamic/Periodic Vehicle Scheduling Problems -- for development of methodologies for analyzing and solving dynamic/periodic scheduling problems, with particular emphasis on routing and scheduling problems in ocean transportation. (James B. Orlin, assistant professor of Management Science, Sloan School of Management; and Harilaos Psaraftis, assistant professor of Marine Systems)

3) Structure and Conduct of the US Auto Industry -- to begin investigations of how domestic aid to producers reacts to shifts in demand or market structure. (Ann Friedlaender, professor of Economics and Civil Engineering)

4) Finance of Transport Innovations -- to begin an investigation of the relationship between transportation innovation (and its funding sources) and public policy aimed at encouraging such innovations. (David Geltner, research associate, (CTS))

5) The Future of the Intermodal Carrier -- to begin research in intermodal container operations, technology, economics, and demand. (Henry Marcus, associate professor of Marine Systems)

6) Load Planning in Trucking Firms -- to develop analytical methods for solving the mathematical problem associated with load planning in trucking operations. (Yossi Sheffi, associate professor, Civil Engineering)

Affiliates Program

The CTS Affiliates Program serves as the principal means for the Center to interact with the private sector. Organizations pay a fee of $15,000 per year with a three-year minimum commitment. The Affiliates Program includes top managment roundtables, personnel exchanges between industry and MIT, seminars, information transfer, and cooperative research projects. The program was inaugurated this year and currently has six charter members -- General Foods, IU International, IBM, Sea-Land, Southern Pacific, and United Parcel Service. Our objective is to have 15 firms by next year, and 30 firms eventually in the program.

DANIEL ROOS

Electric Power Systems Engineering Laboratory

The Electric Power Systems Engineering Laboratory (EPSEL) supports and encourages research and education in the varied disciplines which together constitute the field of electric and electromechanical energy conversion and control. During the past year eight faculty members, five research staff members, and approximately 40 graduate and undergraduate students were engaged in research in the Laboratory.

The major research project in the Laboratory continues to be the design and construction of a 10-MVA superconducting generator using advanced and previously untested concepts. Power electronics research continues to grow, reflecting advances in semiconductor device technology and new application areas. Research in electromechanical energy conversion systems has resulted in an innovative and significant technique for stabilizing the position of magnetically levitated energy storage flywheels. Microprocessors are being used extensively in the control of energy systems, and almost every research project in the Laboratory is using these devices. In recognition of the increasingly important role of the microprocessor in energy systems, a new and very successful laboratory subject, Microprocessor Control of Energy Systems, is now being offered in the Laboratory.

During the past year the Laboratory has undertaken several new initiatives. The role and requirements of electromechanical systems in robotics is being carefully evaluated to identify opportunities for significant contributions. Research in the general area of intelligent control of energy, i.e., exploiting new components for communication and computation, has been initiated. A new MIT-Industry Collegium in Power Electronics was introduced this spring.

This June the Laboratory hosted the 1982 Institute of Electrical and Electronics Engineers (IEEE) Power Electronics Specialists Conference on the MIT campus. This week-long meeting was attended by an international audience of 350.

JOHN KASSAKIAN

Innovation Center

This past year has been the first full year of operation of the Industry/Innovation Center Cooperative Program. This program has been developed to provide a mechanism for product creation and development work to be done at MIT, with the support of member companies desiring growth through new product introduction. Its first year has been a success, with the generation of at least five new products or processes for our subscribing members. At present there are three member companies, with the eventual goal of expanding this to approximately 15. The National Science Foundation has provided a grant to help in the establishment of this program.

Student interest in the Innovation Center remains high, with participation in the classroom subjects and thesis and laboratory projects at about the same level as last year -- approximately 85 students. The new direction of the Center offers more growth opportunity as relationships with the industrial sector are strengthened.

The Innovation Center has begun the process of widening its classroom teaching program. Two subjects are being considered, one with particular emphasis on bringing education in technological innovation to the early undergraduate years in the School of Engineering.

A pilot program with the Boston College Small Business Development Center was initiated to investigate the feasibility of technical assistance to small businesses, under sponsorship of the Small Business Administration. This small pilot program has already demonstrated the educational value of student assistance in this type of program and the benefits to new and existing small businesses in eastern Massachusetts.

DAVID G. JANSSON

Laboratory for Computer Science

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

Founded in 1963 as Project MAC (Multiple Access Computer and Machine-Aided Cognition), the Laboratory developed the Compatible Time-Sharing System (CTSS), one of the first time-shared systems in the world, and Multics -- an improved time-shared system that introduced several new concepts. These two major developments stimulated research activities in the application of on-line computing to such diverse disciplines as engineering, architecture, mathematics, biology, medicine, library science, and management. Since that time, the Laboratory's objectives 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 for an automated "mathematical assistant" by the Mathlab Research Group; and the use of specific knowledge about budgets 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. The networks for such distributed environments are studied by the Computer Systems and Communications Group, while distributed file servers and cryptographic protection techniques are pusued by the Computer Systems Structures Group. Other research in this area includes the architecture of very large 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, entitled "Theory," involves exploration and development of theoretical foundations in computer science. For example, the Theory of Computation Research Group strives to understand ultimate limits in space and time associated with various classes of algorithms, 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 the use of computers in the educational process by the Educational Computing Group; 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 307 members -- 36 faculty and academic research staff, 22 visitors and visiting faculty, 75 professional and support staff, 90 graduate and 84 undergraduate students -- organized into 16 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, Humanities, the Center for Policy Alternatives, and Sloan School of Management. Laboratory research during 1981-82 was funded by 15 governmental and industrial organizations, of which the Defense Advanced Research Projects Agency of the Department of Defense provided about half of the total research funds.

Technical results of our research in 1981-82 were disseminated through publications in the technical literature, through Technical Reports (TR263-TR276) and through Technical Memoranda (TM199-TM220). The following items are the highlights of the year.

The newly established Educational Computing Group has been augmented with additional people from the MIT Division for Study and Research in Education, notably Dr. Sylvia Weir and her researchers. We are embarking on a major effort in the area of computers and education starting from the results of the pioneering work of Professor Seymour A. Papert during the last decade. We hope to establish a broadly based effort by pursuing research in the intersection of computer technology, cognitive science, and education with the objective of improving the human educational process.

Another area of emphasis involves our newly created research group on Functional Languages and Architectures. Here, we are pursuing the eventual construction of a new class of computers consisting of hundreds, if not thousands, of interconnected processors, all working toward the same applications goal. Such goals include speech and image understanding, logical inference, and the solution of large, numerically intensive problems, such as weather forecasting. The new opportunity that motivates us to pursue this work is our progressively increasing ability to construct, via VLSI (very large scale integration) techniques, a large number of identical, complex, and relatively inexpensive computational structures. Our hope is to develop scalable architectures in the sense that doubling the number of elements in such a system will roughly double the performance under the desired application.

During 1981-82, we also have made substantial progress in our distributed systems research. This major laboratory focus continues to occupy the attention of more than half our people. Our recent results have put us in a position to construct a class of geographically distributed and interconnected systems which strive to balance local autonomy with application cohesiveness. The hardware resources that we designed were successfully transferred to industry and we expect to take delivery of the first commercial-level machines before the end of 1982. These and other machines of the single-user variety are expected to form prototype systems within the laboratory starting in 1983. It is through these prototypes that we plan to implement the collection of research results that we have acquired up to now. In particular, we expect to experiment with languages, operating systems, and applications that establish the feasibility of distributed systems. Such feasibility, in turn, means that an aggregate of many such arbitrarily interconnected and decentralized machines can render at minimum all the functions of a single centralized computer environment -- in the presence of local failures which are likely to be frequent as the number of participating machines becomes large.

During 1981-82 Drs. David Lebling, Ramesh Patil, Christopher Reeve, and Gerard Vichniac became research associates; Dr. Marvin Sirbu joined us as associated member, and Dr. Weir as principal research associate. Finally, Albert Vezza was appointed acting associate director replacing Professor Michael Hammer who took a leave of absence for one year.

MICHAEL L. DERTOUZOS

Laboratory for Information and Decision Systems

The Laboratory for Information and Decision Systems (LIDS) is an interdepartmental research laboratory with the primary function of conducting research in systems, communications, and control. Fundamental, theoretical issues and important application areas are among its studies. Computers and computation play a vital role in this research.

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 reporting to the Office of the Provost. On September 20, 1978, its name was changed to Laboratory for Information and Decision Systmes to reflect more accurately the research interests of its faculty, full-time research staff, and students.

As an interdepartmental laboratory, LIDS now reports to the Dean of the School of Engineering, Professor Gerald L. Wilson. The director of the laboratory is Sanjoy K. Mitter, professor of Electrical Engineering. Robert G. Gallagher, professor of Electrical Engineering, is the associate director. The assistant director is Stanley B. Gershwin, principal research scientist.

Thirteen faculty members and seven research staff members are associated with the laboratory. In addition, approximately 60 graduate students conduct research in LIDS. Currently, the laboratory provides 35 research assistantships to graduate students. A number of undergraduate students also participate in research and thesis activities.

Research support has been provided by the American Newspaper 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, and the DuPont Company.

RESEARCH

The current research activities of the Laboratory cover a wide range of theoretical and application areas. The common theme is the critical role played by systems, communications, and control.

Communication Science and Systems

Research in communication science and systems ranges from studies of the underlying theoretical information properties of networks and point to point systems, to architectural design. A major research program in this area deals with reliable, efficient communication in data networks. Some of the topics in this program are routing, flow control, the communication complexity of distributed algorithms, contention resolution in broadcast networks, protocols, failure recovery, and topological design. Professor Gallagher and Professors Dimitri Bertsekas, Pierre Humblet, and their students are conducting this research.

Command, Control, and Communications (C^3) Systems

The study of military C^3 systems defines basic research directions in the areas of distributed detection and estimation, distributed databases, and team decision theory. Professors Michael Athans and Robert R. Tenney, Dr. Alexander H. Levis, and Elizabeth R. Ducot, together with a large group of graduate students, are developing novel theoretical and algorithmic approaches for this rich class of system-theoretic problems. Recent advances have been made in the following areas: a) organization structures based upon information-theoretic concepts, b) mathematical models of distributed decision problems with limited communications, c) multisensor/multi-object tracking algorithms including sensor scheduling, d) integration of distributed database systems within vulnerable communication networks, and e) development of a computer-based testbed in support of the analytical research.

Theory and Algorithms for Optimization

This project focuses on analytical and computational methods for solving broad classes of optimization problems arising in engineering, operations research, applications in communication networks, control theory, power systems, computer-aided manufacturing, and other areas. In addition to traditional subjects in nonlinear and dynamic programming, there is currently an emphasis on solving large-scale problems involving network flows and differential and difference equations dynamics. The thrust there is two-fold: first, to find ways to handle the typically huge number of constraints; and second, to explore the use of distributed and parallel processing in order to reduce the computation time needed to solve a problem and economize on information transfer from remote data collection points to a computation center. This gives rise to fundamental issues involving the synchronization of computation and communication that are as yet only partially resolved. This work is performed by Professor Bertsekas and his students.

Stochastic Systems and Signal Processing

A variety of stochastic estimation, analysis and signal processing problems are being studied by Professors Alan S. Willsky, Bernard C. Levy, S. Shakar Sastry, Professor Mitter, and their students. Theoretical studies are being undertaken in the areas of estimation algorithms, i.e., mapping methods, for spatially distributed random processes, nonlinear filtering, relationships among filtering problems and problems in scattering theory, and the analysis of large-scale systems

subject to a variety of very rare events. Complementing this theoretical research are a variety of more applied projects including the design of algorithms for detecting and compensating for sensor or actuator failures, and the development of model-based signal processing algorithms. The specific signal processing problems include the diagnosis of arrhythmias in electrocardiograms, the detection of objects or anomalies given tomographic measurements (such as those made using X-rays or ultrasound) in medical and industrial nondestructive testing applications, and the analysis and inversion of spatially distributed geophysical data.

Multivariable and Adaptive Control

Systematic design of multiple-input/multiple-output systems, using a unified time- and frequency-domain framework, is an extremely active research area in the Laboratory. Various theoretical and application studies are being carried out by Professors Athans, Levy, Sastry, Professor Gunter Skin, Dr. Lena Valavani, and their students. Theoretical research deals with issues of robustness, aggregation, and adaptive control. Recent application-oriented studies include the control of Vertical Takeoff and Landing aircraft, power system stabilization using multi-terminal DC controllers, turbofan control system designs, and issues of integrated flight control.

Nonlinear Systems

Research in the area of deterministic nonlinear systems focuses on three separate aspects: analysis, including modeling of nonlinear systems and circuits, numerical methods for their simulation including singular perturbation and multiple time scale methods; stability, including the study of static and dynamic bifurcations, complex dynamics, and chaotic behavior; and methodologies for nonlinear control -- especially geometric, sliding mode, or switched and adaptive control systems. Also under study is the qualitative behavior of stochastic nonlinear systems including bifurcations in the presence of small noise as well as nonlinear filtering and estimation of Markov processes from noisy observations. The connections between the nonlinear filtering, stochastic control, and mathematical physics are being investigated. This study is being conducted by Professors Mitter and Sastry, and their students.

Numerical Linear Algebra and Parallel Computing

Recent technological innovations in microprocessor technology, particularly the standard for floating point arithmetic and replicating functional microprocessor units proposed by the Institute of Electrical and Electronics Engineers, enhance the research and design of numerical algorithms for parallel tasking. The programming language, Ada, permits the expression of such algorithms in a recognized high-level language. Research on algorithmic design, partitioning of data, and the failure of algorithms due to sensitivity perturbations of data constitute the main themes of our research (which can have applications in many areas not limited to control and communication). An important ingredient of this research is the construction of an appropriate numerical algorithm in a parallel tasking environment. Virginia Klema, George Cybenko, and Ms. Ducot are responsible for this research at LIDS. Professors Steve Ward and Richard Zippel from the MIT Laboratory for Computer Science also participate in this work.

Manufacturing Systems

Modeling, analysis, optimization, and control of manufacturing systems are studied by Dr. Gershwin and his students. The effects of machine failures on routing and scheduling policies are investigated in order to reduce in-process inventories and to reduce the time spent by material in the factory. The architecture of an on-line computer system which will optimally control the flow of material is being considered. The concept of a transfer (or production) line has been extended to that of an assembly/disassembly network for the purpose of studying the interplay between reliability, speed, buffer size, production rate, and average in-process inventory levels. The FlexMan computer system is being developed by Ms. Ducot to help transfer our results to industrial users.

Information Transfer and Retrieval

Research in information transfer and retrieval focuses on investigations of issues concerning how

computer-based information systems can be engaged more easily and effectively by potential human users. These investigations involve the application of theoretical, analytical, and experimental techniques in areas such as information and computer science and technology, computational linguistics, and psychological human-factor studies.

Three current projects include analytical and experimental investigations of a) electronic document-delivery networks applicable to interlibrary resource-sharing; b) expert computerized intermediary systems to assist end-users in accessing and operating heterogeneous bibliographic databases and retrieval systems; and c) intelligent terminals with microprocessor and telecommunications hardware and software that enable automatic connection and log-in to remote computers. Staff members directing these three efforts are, respectively, Professor J. Francis Reintjes, Richard S. Marcus, and John E. Ward.

PERSONNEL

Professor Wilbur B. Davenport, a long-time faculty member and former Head of the Department of Electrical Engineering and Computer Science retired from the Institute and has joined the faculty of the University of Hawaii.

Professor Sastry, who received his Ph.D. at the University of California at Berkeley, joined the faculty of the Department of Electrical Engineering and Computer Science and is a member of the Laboratory.

SANJOY K. MITTER

Laboratory for Manufacturing and Productivity

The Laboratory for Manufacturing and Productivity continued to grow at a rapid pace this past year. At the end of the 1981-82 academic year, more than 100 researchers from six academic departments were active in a variety of different areas. This makes the Laboratory the largest of its kind among the universities in the US and perhaps second or third largest in the world. It is the leading source of Ph.D.s for other universities as well as for industrial firms. Its strong cooperative links with industry are being examined closely by other universities currently interested in strengthening their manufacturing activities.

Among the highlights of our research activities this past year were the development of the vented compression molding technique, the refinement of the axiomatic approach to design, further innovation in the robotics area, and new techniques for evaluating productivity in R&D organizations. The vented compression molding technique, developed for the National Aeronautics and Space Administration under the sponsorship of Martin Marietta Corporation, permits ablative materials used on the exterior fuel tank of the Space Shuttle to be molded more reliably and easily than was previously possible. The technique will save tens of millions of dollars over the Shuttle Program. In axiomatics, the nature of coupling among functional requirements of a design has been elucidated and mathematical measures of the degree of coupling developed, thus furthering analytical capability in automatic design evaluation. In robotics, new control schemes and direct drive manipulator arms show great promise of increasing the accuracy of robot manipulators. In productivity analysis, techniques drawn from several disciplines permit reliable estimation of effectiveness and productivity in "knowledge work" organizations such as R&D.

As a further expansion of its activities with industry, the Laboratory has established a new cooperative research program with industry, the Tribology Research Program, under the direction of Professor Ernest Rabinowicz.

The contributions made by the members of the Laboratory for Manufacturing and Productivity have been well recognized by awards and citations. Professor Lewis Erwin and graduate student John McCree were given special recognition for their contribution to the Space Shuttle Program by Martin Marietta; Gregory Rickelman and Professor Erwin were given a best paper award by the Society of Plastics Engineers; Professor Nam P. Suh's paper on the delamination theory of

wear was chosen as a citation classic by the Institute of Scientific Information; he and graduate student Joe R. Youn were given the best paper award by the Society of Plastics Engineers; Professor Bruce M. Kramer and Professor Suh were chosen for the Blackall Machine and Tool award by the American Society of Mechanical Engineers (ASME); and Professor Nathan H. Cook was elected a Fellow of ASME in recognition of his contributions to the manufacturing field.

New personnel joining the Laboratory this past year included Professors Timothy Gutowski (polymer processing, composites), Ming-Kai Tse (nondestructive evaluation and polymer and fiber processing), and Haruhiko Asada (robotics). A number of new industrial sponsors have joined our efforts, including General Electric Corporation, IBM, DaeWoo Heavy Industry, Matsushita Electric Industry, Daikin Industry, and Shin Meiwa Industry. More than 65 percent of the Laboratory's annual research budget of approximately $1.7 million now comes from the industrial sector.

MICHAEL B. PACKER

Materials Processing Center

The central thrust of activities of the Materials Processing Center remains the transition or "action" stages of the well-known "Materials Cycle." These comprise extraction, processing into bulk materials, processing into engineering materials, fabrication, recycling, and disposal. Center activities encompass all engineering materials including metals, ceramics, polymers, electronic materials, composites, superconductors, and thin films.

The total annual funding of the activities of the Center, now in its third year of operation, has grown to more than $3 million, which includes industrial support of approximately $1 million. Strong support is also provided by the National Aeronautics and Space Administration and other government agencies. Major research programs are under way in the following areas: rapid solidification processing, ceramic processing and engineering, materials systems, welding, semiconductor processing, electronic materials, chemical metallurgy, non-destructive evaluation, polymer processing, electroprocessing, mathematical and physical modeling, corrosion, mechanical properties, solidification processing, and computer-aided processing. Research efforts in these areas over the past year are outlined in the annual report of the Materials Processing Center.*

During the past year, a generous gift from Toyota Motor Company to MIT established the endowed Toyota Professorship of Materials Processing, which was awarded to the director of the Center, Professor Merton C. Flemings. The associate director of the Center, Professor Harvey Kent Bowen, was awarded the endowed Ford Professorship of Engineering. In addition, Norton Company has provided funds for three years for an assistant professorship of Materials Processing, and that position has now been filled by Professor Gretchen L. Kalonji.

During 1981 the Center took a major step forward in expanding the scope of its direct interaction with industry through the initiation of a "Collegium" with industry. The central goal of this Collegium is to provide a mechanism for improved interaction of Center faculty, staff, and students with industry personnel; it operates in close cooperation with MIT's Industrial Liaison Program. To date, more than 30 companies have joined or have agreed to join the Collegium. Membership fees provide funds for fellowships in materials processing, badly needed equipment, and seed research projects.

Periodic workshops are held as part of the Collegium activities. The first of these, held in April 1982, covered Rapid Solidification Processing and attracted 65 participants from 29 companies and four government agencies. The second Collegium workshop is planned for early October 1982, on "Mathematical and Physical Modeling of Materials Processes." The specific aim of these workshops is to provide a forum for faculty, staff, students, and industry representatives to exchange ideas, identify innovative research opportunities, and arrange cooperative or sponsored research and development programs.

MERTON C. FLEMINGS

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* Materials Processing Center Annual Report, 1981, School of Engineering, Massachusetts Institute of Technology.

School of Humanities and Social Science

The news from Washington regarding funding for the arts, humanities, and social sciences continued mixed this year. The National Science Foundation fellowships, which are so important for the Department of Economics, were rescued at the eleventh hour, but the National Institute of Mental Health training grant in Linguistics was not renewed. With the overall decline in real terms in the level of government funding, there is in the School a sense that research opportunities are contracting, although the extent of the contraction differs greatly from field to field. As the Institute continues to cut back its own expenditures the sense of declining opportunities is certain to intensify. Therefore, there are bound to be difficult years ahead. Faculty members will feel increasingly frustrated unless alternative sources of research support are quickly developed.

In the short term, it looks as though the departments in the School will be able to maintain their existing levels of activity. But it will be a continuing struggle, as it has been for several years past, to hold onto those younger faculty members who are regarded as the rising stars in their disciplines. And it will be increasingly difficult to persuade faculty members that new areas of research should be developed, when other areas, which have been the greatest source of strength in past years, are underfunded. Yet we must be prepared to move in new directions if the end of expansion is not to lead to stagnation.

One special problem will continue to afflict this School. Until the last few years faculty salaries were roughly comparable right across the Institute. Increasing demand for faculty members in such fields as Economics, Management, and Computer Science, at a time when the number of Ph.D.s is not increasing fast enough to keep up with demand, has led in most universities, including MIT, to the abandonment of the old tradition of roughly comparable salaries. In fields where demand is weak, such as French Literature and most other branches of the Humanities, we face a future in which the salaries of full professors will be comparable with those for beginning assistant professors in fields where demand is strong. Salaries in some professional schools have long been higher than in the faculties of Arts and Sciences, but the differences have been tolerated because they were between different organizations. Now we have a situation in which even within the Humanities and Social Sciences salaries will differ sharply from department to department. The differences in life style which follow from differences in salary will not be easy to bear, and we must not lose sight of the need, when times are more propitious, to reinforce the sense of collegiality which has hitherto distinguished most colleges of Arts and Sciences by restoring a less divisive salary structure.

As in so many past years, we have once again been grappling with the need to find an organizational structure for the Department of Humanities that is capable of enhancing the professional lives of the faculty and encouraging teaching of the highest quality. This time, with the cooperation of the faculty, we think we have found a viable means of giving new flexibility to the administrative structure without incurring unjustifiable expenses. When the new academic year opens, the six sections and programs of which the Department of Humanities is composed will become autonomous. The Department Headquarters will be phased out. Section heads will become members of the School Council and begin to function as heads of quasi-departments. Professor Peter Smith will cease to be department head and devote himself full time to the post of associate dean of the School. The first stages of the transition will be difficult ones, but it is our hope that by January 1983 the new structure will be in full working order.

HAROLD J. HANHAM

Note: Detailed enrollment figures for the School are available in the archival version of this report and from the Dean's office.

Department of Economics

The dominant problem of the Department continued to be the uncertain continuation of the National Science Foundation (NSF) Fellowship program upon which we are heavily dependent. Of our graduate student body of around 100 students, 39 are NSF Fellows -- over half of our US students. Moreover, the number of NSF Fellows who elect to come to our Department constitute almost half of the national total in economics. In 1981, the Reagan Administration attempted to abolish completely the NSF Fellowship program, but by the end of the calendar year Congress extended it. This last-minute reprieve and the inclusion of the program in the budget for fiscal 1983 does not provide assurance that the program will be permanently continued. We have, therefore, been involved this year in the organizing and initiating of a major program of fundraising that will substantially reduce our reliance on NSF Fellowships for student support.

The NSF grant program in the social sciences was initially cut by 80 percent. While some restitutions have been made, this much smaller program will have a serious, although not disastrous, impact on the field and the Department -- falling with greatest force on younger and less well known faculty.

Computational facilities and costs have been a growing problem of the Department over recent years. Happily, they appear to have been solved this year with the installation in the East Campus Computer Facility of a PRIME 850. A steering committee drawn from the Department and the Energy Laboratory and chaired by the Sloan School was also established to guide this greatly expanded computational resource. For both faculty and students in social science, it will enhance output at a considerably reduced cost.

Spatial problems which have plagued the Department for several years appear to be moving toward a resolution. By the end of the next academic year, a quantity of contiguous office space adequate for our needs for the next few years will be available in the Sloan Building. Its quality and arrangement will, however, need considerable upgrading.

Our graduate student body has been reduced by about 10 percent, partially the result of the uncertainty of student financial support. Undergraduate majors have shrunk by the same percentage when compared with the last half of the 1970s. We were surprised by a sharp drop in enrollments in introductory economics following large increases in 1980 and 1981, even while total enrollments in the more advanced subjects remained virtually unchanged. We are especially puzzled since the advanced registration for next fall indicates the largest introductory enrollment we have ever had.

Faculty research has been conducted in many areas and published in a variety of forms too numerous to detail: social experiments, their design, labor supply and efficiency implications (Professor Jerry A. Hausman); energy problems, i.e., industry structure (Professor Morris A. Adelman), regulation and cogeneration (Professor Paul L. Joskow), demand and supply modeling (Professors Hausman and Daniel L. McFadden), and synfuels (Professor Martin L. Weitzman); international exchange rate regimes (Professors Rudiger Dornbusch and Paul R. Krugman); transportation industries (Professors Ann F. Friedlaender and McFadden); unionism and the structure of labor markets (Professors Henry S. Farber, Michael J. Piore, Robert M. Solow, and Lawrence H. Summers); health economics and regulation (Professors Jeffrey E. Harris, Joskow, Marilyn J. Simon); search theory and the micro aspects of macro theory (Professors Peter A. Diamond and Solow); inflation and financial markets (Professors Franco Modigliani and Summers); productivity (Professor Lester C. Thurow); and economic development problems (Professors Dornbusch, Richard S. Eckaus, Timothy J. Kehoe, and Lance J. Taylor).

The faculty have received a number of honors this year. Professor Adelman continued as president of the International Association of Energy Economists, Professor Modigliani as president of the American Finance Association and vice president of the International Economic Association, and Professor Friedlaender was elected to the executive committee of the American Economic Association. Professor Jerome Rothenberg is serving as national chairman of the Committee on Urban Public Economics. Professor Robert L. Bishop was named to the Council of the American Academy of

Arts and Sciences. Professor Diamond gave the Fisher-Schultz Lecture of the Econometric Society and the Wicksell Lecture of the Stockholm Institute of Economics, and he will be a Guggenheim Fellow next year; Professor Modigliani will give the Marshall Lecture at the University of Cambridge. Professor Joskow was voted the best teacher in economics by the Graduate Economics Association. Professor Thurow received the Loeb Prize for the best economics writing in 1981. Professor Paul A. Samuelson received honorary doctorates from Widener College and the City University of London, and Professor Solow from the University of Geneva.

Several changes in faculty personnel are reported. Away all year were professor Stanley Fischer as Visiting Fellow at the Hoover Institute, Stanford University; Professor Franklin M. Fisher as Guggenheim Fellow and Visiting Professor at Harvard University; and Professor Eric S. Maskin as Fellow of Churchill College, Cambridge University. Professor Weitzman was on sabbatical leave in the fall. Two assistant professors resigned this year: Robert B. Litterman, in order to continue with the Federal Reserve Bank of Minneapolis, and Thomas J. Teisberg, in order to remain with Natomas Corporation. Teaching needs were met by the appointments of Visiting Professors Michael Bruno of Hebrew University and Kevin W.S. Roberts of the University of Warwick for the fall term; Dale J. Poirier of the University of Toronto, Robert J. Shiller of the University of Pennsylvania, and Gordon R. Sparks of Queen's University for the academic year; and Thomas G. Cowing of the State University of New York, Binghamton for the spring term. A popular set of lectures was given this year during the Independent Activities Period (IAP) by Professor James Heckman of the University of Chicago.

Well-deserved promotions were earned by Professor Harris, a joint appointee with the Whitaker College of Health Sciences, Technology, and Management, to associate professor with tenure; and Professor Summers, appointed to the Class of 1922 Career Development Chair, to professor of Economics. Henry S. Farber's promotion to associate professor and Eric S. Maskin's promotion to professor became effective this year. Three new appointments have been made for next year: James M. Poterba from Oxford University as instructor for the fall term, and James C. Powell and Garth Saloner, both from Stanford University, as assistant professors.

Administrative changes beginning next year will place the Department in capable hands: Professor Joskow as Associate Head and Professor Friedlaender, after a fall term sabbatical, as Head.

E. CARY BROWN

Department of Humanities

The members of the Department of Humanities had a busy and productive year. The following reports provide clear and thorough explanations of the activities in the various Department sections and in the Course XXI office. This statement merely serves to emphasize a few selected themes.

The first has to do with curriculum and, in a sense, with the overall role of humanities at MIT. The Institute faculty's decision to adopt a Writing Requirement is likely to have far-reaching implications for the Department and, more specifically, for the Writing Program. We have already established a drop-in Writing Center. Other initiatives will depend upon the mode of implementation of the Requirement, and here we will help in any way we can.

The Committee on Educational Policy's current study of the Humanities, Arts, and Social Sciences (HASS) Requirement also bears on the Department of Humanities, whose faculty does most of the teaching for the Humanities Distribution subjects. We generally support the concepts of both "distribution" and "concentration" requirements. It is their specific formulation that prompts speculation and concern, and we look forward to taking part in discussions on these basic issues.

Still another curricular theme deals with interdisciplinary collaboration, and here substantial strides were made this year. We joined with the Program in Science, Technology, and Society to devise a new double-major degree program (with a science or engineering field) in Course XXI. With colleagues in the Department of Political Science and other departments we created a concentration

and joint-major program in Latin American Studies. And after consulting with faculty at Wellesley and around the Institute, we initiated a concentration in Women's Studies. None of these innovations involved new demands on Institute resources.

Scholarly research and artistic creativity have continued at an accelerating rate. During the past year Department members won awards and fellowships from such granting agencies as the American Council for Learned Societies, the National Endowment for the Humanities, and the John Simon Guggenheim Memorial Foundation. There has been a steady stream of books, articles, papers, and other work -- in fiction, for instance, poetry, and musical composition.

As Department Head I have participated in the administrative changes noted below and have also attempted to remain active in my professional field. I completed a term as president of the Latin American Studies Association (LASA), a national organization; gave talks at Harvard, the University of Connecticut, St. Olaf's College, the University of Texas, and at LASA's national meeting; published a policy statement on US-Mexican relations for the US Senate; and, most gratifyingly, gave a course on Mexican politics here at MIT.

At the end of the academic year considerable changes in the structure of the Department were under discussion. By the time next year's reports come to be written it is to be expected that there will have been major changes. In particular, the sections of the Department will have gained much greater autonomy. Already, most of the activities in the Department are entrusted to the sections. Next year they may be expected to assume virtually complete control over curricular, appointment, and budgetary affairs.

PETER H. SMITH

ANTHROPOLOGY/ARCHAEOLOGY PROGRAM

During the 1981-82 academic year the most important events for the Anthropology/Archaeology Program were the arrival of two new faculty members and the program's move to new quarters in Building 20. The move was accomplished in two stages. During the summer of 1981 Professor Wilma Wetterstrom supervised the creation of a program teaching lab in Room 20B-136, and in January 1982 faculty offices and a department center were renovated in time for occupation at the beginning of the spring semester.

In September 1981 Professor Suzanne De Atley, who had held a postdoctoral research fellowship at the Smithsonian in Washington, DC, joined the Anthropology/Archaeology Program on a joint appointment with the Center for Materials Research in Archaeology and Ethnology. Professor Sharon Traweek, who taught at Stanford University during 1980-81, spent fall 1981 finishing her dissertation and then joined the program in January 1982 -- along with the Program in Science, Technology, and Society (STS), with whom she has a joint appointment.

During her initial year at MIT, Professor De Atley organized the first Summer Institute of the Center for Materials Research in Archaeology and Ethnology. She coauthored "Regional Integration on the Northern Casas Grandes Frontier," which appeared in *Proceedings of the Mogollon Conference*; and "Comparison of Data Obtained by Neutron Activation and Electron Microprobe Analyses of Ceramics" in "Archaeological Ceramics" (in press). In January 1982 Professor De Atley gave an invited lecture at the Smithsonian, "Some Archaeological and Geological Aspects of Ceramic Manufacture in the Prehistoric Southwest." In addition to her laboratory research, for which she won a 1981-82 grant from the Sloan Fund for Basic Research, she carried out a field geological survey of ceramic materials in Southeast Utah, and she plans further fieldwork in the Southwest during summer 1982. Professor De Atley has been named a research associate of the Smithsonian for a term of three years, and she continues as editor of the newsletter of the Society for Archaeological Science.

Professor Martin Diskin spent a busy year speaking on Central America, at Assumption College, MIT, Harvard, Berkshire Community College, Smith College, University of Washington (Seattle), and Johns Hopkins University, and for the Harvard Club of Boston and the Association of Retired Professionals. He gave a paper entitled "Fire in the Lake II?" at the American Anthropological

Association Meetings in December 1981, and another entitled "Moskito Nation-Sandinista State: Context for Dialogue" at the American Ethnological Society Meetings in April 1982. During the year, his paper entitled "The Peasant Family Archive" appeared in *Ethnohistory*, and "Land Reform in El Salvador: An Evaluation" was published in *Culture & Agriculture*. He traveled to Central America twice, in the summer of 1981 and December-January 1981-82, to survey conditions there. He currently is completing a publication for Pantheon Books on Central America, which is due to be published in February 1982. He is the first year's winner of the John Navas Faculty Foreign Travel award given in "recognition of outstanding teaching capability."

Professor James Howe completed his first year as Head of the Anthropology/Archaeology Program. In that capacity he served on the Departmental Section Heads Committee and the Advisory Committee on Personnel, and he chaired a special subcommittee of the personnel committee. Professor Howe contributed to the editorial and research committees of the organization CAMINO for their book, *El Salvador, Background to the Crisis* (as did Professors Diskin and Heather Lechtman). In November, as special consultant to the Smithsonian Institution, he delivered a speech on its behalf to the Kuna council of chiefs in Panama. At the spring meetings of the American Ethnological Society, he organized a session on "Indigenous Peoples, the State, and National Society in Central America," in which he also gave a paper. Professor Howe is principal organizer for a session on development and change and the indigenous peoples of Panama at the 44th International Congress of Americanists in Manchester, England, September 1982, in which several Indian leaders will participate.

Professor Jean Jackson devoted considerable time and effort to organizing a Women's Studies Concentration. In the Department of Humanities she served on the Curriculum Committee and a special personnel subcommittee, and she organized and cosponsored an Independent Activities Period offering on Native Americans and Development. Outside the Department, she served on the HASS Committee, the Experimental Study Group Advisory Committee, and the advisory committee for the Joint Harvard-MIT Group on Women in International Development. Professor Jackson's book, "The Fish People: Linguistic Exogamy and Tukanoan Identity in the Northwest Amazon," is in production at Cambridge University Press, and two articles based on her researches in the Colombian Amazon are due to appear in *Sex and Gender in Fieldwork* and *Marriage Practices in Lowland South America*. She delivered several talks this year, one to the Association of Women Students on "Women and Evolution," one to the Tech Wives Group on "Women's Work in the Modern World," and one to the Panamerican Society of Boston.

Professor Lechtman continued as head of the Center for Materials Research in Archaeology and Ethnology (CMRAE) and of the CMRAE Graduate Laboratory. She organized and solicited outside funding for a CMRAE Summer Institute given to students and faculty from all over the US, and during June she is teaching the Summer Institute's first course on Metals in Ancient Societies. Within MIT she is a member of the following organizations: the Institute Committee on the Visual Arts; the Institute Committee on Equal Opportunity; the Steering Committee of the Program on Technology and Development; and the Metallurgy Panel, the Materials Engineering Panel, and the Ad Hoc Committee on Materials Science, Humanities and the Arts in the Department of Materials Science and Engineering. As a member of the last committee, Professor Lechtman raised funds for the newly established Kathryn Langford Wolfe Prize for undergraduate projects in Materials Science and Humanities or the Arts. Along with Professor Leo Marx, she represented MIT at the December 1981 Wellesley-Sloan Conference on Liberal Arts, Technology, and Undergraduate Learning.

Outside MIT, Professor Lechtman served on the Committee on Anthropological Conservation of the National Conservation Advisory Council; and visiting committees to the research laboratory and Department of Primitive and PreColumbian Art of the Boston Museum of Fine Arts. She is chair of the judging committee for the Leon Pomerance Award for Scientific Contribution to Archaeology (of the Archaeological Institute of America), and of the Center for Archaeological Research and Development of the Peabody Museum at Harvard University. She is editor of *Art and Archaeology Technical Abstracts*.

A 500-page volume on Andean technology, *La tecnología en el mundo andino*, for which Professor Lechtman is coeditor, was published in Mexico in late 1981. She is currently editing volume two of the series, supported by a grant from the Tinker Foundation. A coauthored paper on Moche metallurgy was published by *American Antiquity* in early 1982, and a book review of *Ars Orientalis II* appeared in late 1981.

In addition to ongoing laboratory research on ancient Andean arsenic and tin bronze manufacture, which is supported by the American Smelting and Refining Company, Professor Lechtman is preparing for a major long-term fieldwork project in the Andes, to begin in January 1982.

During 1981-82 Professor Arthur Steinberg coauthored "Ancient Mining and Mineral Dressing in Cyprus," to appear in *Early Pyrotechnology*, and "Technology of Halaf Pottery," to appear in *Festschrift for Frederick Matson*. In late spring 1982 he finished a paper on Ubaid Pottery of Mesopotamia. Professor Steinberg served on the Program committees of the CMRAE and the Boston Society of the Archaeological Institute of America. Within the Humanities Department Professor Steinberg participated in curriculum planning for the Western Tradition Program, and he served as concentration advisor for the Anthropology/Archaeology Program.

Professor Traweek joined the Program in January 1982 on a joint appointment with STS, after finishing her dissertation at the University of California at Santa Cruz. In February 1982 she gave a paper at the International Conference on Colliding Beam Facilities at Stanford. A talk given later in the spring to the Division for Study and Research of Education at MIT will be appearing in their publication series. Professor Traweek has submitted a paper on Walbiri iconography to the journal *Man* and a revised version of her dissertation to Princeton University Press. She has been invited to submit another paper to *Social Studies of Science*.

Professor Wetterstrom was promoted to the rank of associate professor during the 1981-82 academic year. She spent the early summer of 1981 designing and supervising the construction of a new teaching lab for the Anthropology/Archaeology Program, and in August she traveled to Egypt for paleoethnobotanical field studies. During the year she carried out laboratory analysis of botanical materials, and during summer 1982 she plans to travel to Syria for further fieldwork.

Professor Wetterstrom won the Edmund H. Fulling Award for the most outstanding paper presented at the July 1981 meetings of the Society for Economic Botany. She also was invited to give papers on her ethnobotanical researches in the Middle East at the third annual Colloquium on Sardinian Archaeology at Tufts University in November 1981, and at the University Museum of the University of Pennsylvania in March 1982.

Professor Wetterstrom published two book chapters in 1981, one in *Quseir al-Qadim 1980: Preliminary Report*, and the other in a report on an archaeological project in Sardinia. A monograph, "Food, Nutrition and Population at Prehistoric Pueblo Arroyo Hondo," is in press with the School of American Research in Santa Fe, as is a book chapter in "Predynastic Studies in the Nagada-Khattara Region of Upper Egypt."

JAMES HOWE

FOREIGN LANGUAGES AND LITERATURES SECTION

The academic year 1981-82 was marked by three major developments in Foreign Languages and Literatures: 1) a strengthening of the curriculum, 2) significant personnel appointments and promotions, and 3) a reinforcement of the leadership position of the faculty and staff through their scholarly activities worldwide and their sponsorship of special programs at MIT.

Curriculum

Enrollments in Foreign Languages and Literatures attained a record high in the history of the Section: 1,041 students in fall 1981 and 847 students in spring 1982. Though enrollments in French (611) and German (430) continued to remain higher than those in Spanish (315), enrollments in Spanish increased from academic year 1980-81 by about 150 percent. Much of the increase is attributable to an expansion of the curriculum in Spanish language, literature, and civilization. Among new subjects offered in 1981-82 were 21.279 Spanish Conversation, 21.284 Introduction to Latin American Culture, 21.287 The Modern Short Story in Spain and Latin America, and 21.294 The Family in Spanish American Literature. Two new subjects in French, 21.226 Introduction to the French Short Story and 21.227 Representations of Love in French Literature, filled the need for one additional subject in a literary genre and one thematic

subject that links works from the Middle Ages through the 20th century. The introduction of two new subjects in German filled similar gaps: 21.241 German Culture and Society: 1933-1949 offered students historical, sociological, and literary perspectives on the theory and practice of National Socialism, and 21.245 Heinrich Heine, provided in-depth study of the most influential writer in post-Napoleonic Germany.

Subject 21.330 Development of Communication Skills: English as a Foreign Language was designed to meet the needs of high-intermediate and advanced students for whom English is not the primary language of instruction in secondary school and/or college. With the support of the Dean of the Graduate School and the Committee on Graduate School Policy, the Section's testing program in English for incoming international students has been made more rigorous and effective. Mandatory participation by all graduate departments and their new international students whose primary language of prior instruction is not English will take hold officially in fall 1983.

Personnel

Three nationwide searches resulted in three appointments to begin July 1, 1982. Manuel Delgado holds a Ph.D. from the University of Texas at Austin, and has been appointed an assistant professor in Spanish; his principal area of concentration is Spanish Medieval and Renaissance literature, and he will be responsible for teaching Spanish *Siglo de Oro* literature. Dr. Judith A. Davidson, who did her graduate work at the University of Massachusetts in medieval studies, has been appointed lecturer in German, and will have major responsibilities in our German language program. Christopher Sawyer-Laucanno holds a Ph.D. in comparative literature from Brandeis; after several years of experience at teaching English in Japan, he will assume responsibility as a lecturer in English as a Second Language.

The personnel profile of the Section changed in other significant ways. Assistant Professor Elizabeth Garrels, a specialist in Latin American letters, was promoted to the rank of associate professor without tenure. Assistant Professor Jay Rosellini, whose scholarly work currently focuses on contemporary German writers, was also promoted to associate professor without tenure. Associate Professor Edward B. Turk, a specialist in French 17th-century literature and the French cinema, was granted tenure. Professor Turk will become head of the Foreign Languages and Literatures Section as of July 1, 1982 for a period of three years.

The character of the faculty and staff was enriched this year by two special exchange programs. In the spring semester, Senior Lecturer Claire Kramsch was invited to teach at the Ecole Normale Supérieure de Telecommunications in Paris; in exchange, Barbara Fietkau, head of the German Section at the Ecole, joined our faculty as a visiting professor in German. With the assistance of Bernard Genton, cultural attaché to the French Consulate in Boston, Professor Turk initiated a trial student exchange program between MIT and the Ecole Normale Supérieure, Rue d'Ulm. Anne Mercier, an MIT doctoral candidate in political science, spent the year working on issues of French regional industrialization; in exchange, Foreign Languages and Literatures profited from the presence of a recent graduate of the Ecole, Alain Vaillant, a specialist in classical and modern languages, who, as a visiting lecturer, offered numerous lectures and workshops to complement our curriculum in French. Both these experiences provided further intellectual diversity within the Section.

Special Programs at MIT

Extracurricular events constitute an essential part of the educational activities furnished by the Section. These events are typically planned to complement specific curricular offerings, but they are open to the entire MIT community. Among the 30 or more special events this year, those which attracted significant numbers included a film festival entitled "Satire, Irony and Humor in the New German Cinema," sponsored in cooperation with the Goethe Institute of Boston; a lecture by Professor Barbara Monter of the University of British Columbia on "The Russian Heroine: Where to Find Her and Where Not To"; a lecture in Spanish by Professor Efrain Barradas entitled "Poesia Negra del Caribe"; and a talk on "The Heritage of Cyril and Methodius in Russia: by Professor Dimitri Obolensky of Oxford University. A unique event, called "Francolloque" was organized by Lecturer in French, Gilberte Furstenberg. The colloquium brought together prominent members of the Acadian, Haitian, French, Franco-American, and French academic communities of New England to discuss linguistic, cultural, and political issues of general and particular concern.

The highly publicized event underscored the Section's growing reputation as a significant force in the fostering of Francophonic language, literature, and culture in this area of the country. In June, Lecturers Furstenberg and Jacqueline Hill brought students from regional high schools and colleges to participate in a "French Language Immersion Weekend" and to test hypotheses related to intensive language acquisition.

Professional Activities and Scholarly Publications

Members of the Section continued to publish widely and serve in leadership capacities in scholarly organizations this year. The following enumeration is simply a sampling of the variety of research and activities recently accomplished. Professor Julia Alissandratos's book, *Medieval and Patriotic Eulogies*, has gone to press in Florence, Italy, where it is to be published by Studia Historica et Philogica; Professor Alissandratos also chaired the Dostoevsky Section of the American Association for the Advancement of Slavic Studies in Monterey, CA. Two articles originally published in this country in 1977 by Professor Catherine Chvany, "The Grammar of *dolzen*: Lexical Entries as Function of Theory" and "Syntactically Derived Words in a Lexicalist Theory" are to be translated and reprinted in the USSR. Professor Kathryn Crecelius' article on "Merimee's 'Federigo': From Folktale to Short Story" appeared in *Studies in Short Fiction;* Professor Crecelius was also the recipient of a Camargo Foundation grant in fall 1981 and, simultaneously, an American Council of Learned Societies research grant. Professor Isabelle de Courtivron's anthology *New French Feminisms* (1979) went into a third printing in this country this year, and is about to appear in a British edition; she was a featured speaker at Harvard's forum in March on Women in Contemporary France. Professor David Dollenmayer, whose first-year college text *Deutsch im Kontext* is now in press, published a review of Joseph Roth's *Radetkymarsch* in *Modern Austrian Literature*. Professor Suzanne Flynn presented a paper, "A Universal in Second Language Acquisition Based on a Principal Branching Typology," presented at the 11th annual University of Wisconsin at Milwaukee Linguistics Symposium in March 1982. It has been accepted for publication by Newbury House publishers. Lecturer Furstenberg conducted a workshop on the French Immersion Experience at the Massachusetts Foreign Language Association and is editor of "Le Trait d'union," a newsletter of the Union des Francais a l'etranger.

Professor Garrels, who spoke on theoretical aspects of paternalism in Latin American literature at the New England Latin American Studies Association Conference at Brown, is the recipient of a Social Science Research grant that has allowed her to pursue research on non-whites, women, and children in Spanish American Literature. Professor Michael Geisler continued to be active in the German Literature after 1945 section of the Northeast Modern Language Association; his book, "Die literarisch Reportage in Deutschland," was accepted for publication by Scriptor-Athenaum. Professor James Harris's research involving morphological and prosodic structures of the Spanish language has resulted in the publication of the book *Syllable Structure and Stress in Spanish: A Nonlinear Analysis* (MIT Press). Professor Robert Jones's monograph, *Lenormand*, is in press with Twayne Publishers, Boston. Lecturer Kramsch published *Discourse Analysis and Second Language Teaching* with the Center for Applied Linguistics, Washington, DC; this book is being used widely for training teachers both in the US and in Europe. Ms. Kramsch's essay, "Teaching Discussion Skills: A Pragmatic Approach," published in *Foreign Language Annals*, won the Stephen A. Freeman award from the Northeast Conference for the Teaching of Foreign Languages as the best article of the year. Lecturer Douglas Morgenstern addressed the American Council on the Teaching of Foreign Languages in Denver, and his *Manual del instructor* to accompany *¿Habla español?* has been published by Holt, Rinehart, and Winston.

Professor Krystyna Pomorska's article in Russian, "Mayakovsky and Time," appeared in the journal *Slavica Hierosolymitana*, her book *Dialogues*, coauthored with Professor, Emeritus, Roman Jakobson, was reprinted in Russian translation (Slavica Hieroslymitana, Jerusalem) and in German translation (Suhrkamp). Professor Margery Resnick, who presented papers on poetry in post-Franco Spain and bibliographical problems in Women's Studies at the meetings of the Modern Language Association, completed, with Professor de Courtivron, an annotated bibliography of international women writers in translation. Professor Rosellini's book on the East German author Volker Braun is about to appear from C.H. Beck Verlag (Munich); his article "Zur Funktionsbestimmung des historischen Romans in der DDR-Literatur" was published in the anthology *DDR-Roman und Literature gesellschaft*. Professor Turk's essay, "Verbal Game Play in Rotrou's *La Soeur*," appeared in *Papers on French Seventeenth-Century Literature*.

EDWARD BARON TURK

HISTORY SECTION

This is the first time in several years in which no new names were added to the History Section's regular faculty. The history curriculum was, however, enhanced by the addition of subjects in Latin American history taught by Professor Peter H. Smith, the Department Head, and in Middle Eastern history taught by Professor Philip Khoury, who was appointed as assistant professor after a national search during the academic year 1980-81. The Section was fortunately able to persuade Professor Khoury to remain at MIT despite an attractive offer from Stanford. Soon thereafter, however, Professor Alan Brinkley, who has been an assistant professor and popular teacher of modern American history since he joined the Section in 1978, accepted an appointment as Dunwalke Associate Professor of History at Harvard.

Professor Brinkley's absence will be sorely felt particularly next spring, when Professor Pauline Maier, another of the three American historians who are fulltime in the Section, will be on professional leave, serving as Cardozo Professor of History (a visiting appointment) at Yale University. Moreover, Professor Merritt Roe Smith, an American historian in STS who is also affiliated with the History Section, will be absent throughout calendar 1983, working at the Smithsonian Institution in Washington, DC.

In the past few years, the Section's offerings in American History have been enriched by a series of visiting or part-time appointments. This year Professors Ellen Fitzpatrick and Elizabeth Pleck supplemented the regular faculty, with Professor Pleck offering a subject in Women's History that contributed not only to the History Curriculum but to that in Women's Studies. The Section plans to make further visiting or part-time appointments for next year, and a search for that purpose is in progress.

The Section also has continued its recruitment effort under the "continual search" mandate issued by the Institute administration this past year in an effort to increase the number of minority members on the MIT faculty. As part of that effort, Professor Nell Painter of the University of North Carolina at Chapel Hill, spoke to the Section about her work in May 1982.

The composition of the History Section has been affected, finally, by the continued absence of Professor Thomas Mahoney, who continues to serve as Secretary of Elderly Affairs for the Commonwealth of Massachusetts. Professor Mahoney has, however, announced an intention to return to his position at MIT in January 1983.

Professor Smith's appointment at the Smithsonian Institution and Professor Maier's appointment as Cardozo Professor at Yale are only two of the honors awarded members of the Section during 1981-82. Professor Smith was also awarded a Guggenheim fellowship. Professor Brinkley's article, "Huey Long, the Share-Our-Wealth Movement, and the Limits of Depression Dissidence" was awarded the Robert Brown Prize for the best article in *Louisiana History* during 1981, and Professor Maier won the New England History Teachers' Kidger Award for "distinguished service" to the profession. Professor Robert I. Rotberg has been awarded a three-year National Endowment of the Humanities research grant for a biography of Cecil Rhodes which he is writing with Miles Shore, Bullard Professor of Psychiatry at the Harvard Medical School.

The numerous publications by members of the Section include book reviews in scholarly journals as well as in more popular publications such as *The Atlantic*, *The Boston Globe*, *The New York Times Book Review*, and *Choice*. Many articles were also published, including Professor Brinkley's "The New Deal and the Reform Legacy" in the *Wilson Quarterly*, and "Stumbling Toward the Welfare State" in *Reviews in American History*; Professor Maier's "Boston and New York in the Eighteenth Century" in the *Proceedings of the American Antiquarian Society*; Professor Khoury's "Factionalism among Syrian Nationalists during the French Mandate" in *International Journal of Middle Eastern Studies*, and "The Tribul Shaykh, French Tribal Policy, and the Nationalist Movement in Syria between Two World Wars" in *Middle Eastern Studies*; Professor Bruce Mazlish's "The Quality of 'The Quality of Science'" in *Science, Technology and Human Values*, and "American Narcissism" in *The Psychohistory Review*; Professor Peter C. Perdue's "Waterworks and Dike Construction on Tung-t'ing Lake, Hunan, 1500-1850," in the *Journal of Asian Studies*, and "Temporal Trends and Distribution of Granary Reserves in China, 1700-1850," which was scheduled for publication in a book entitled *Granaries in Ch'ing China*; and several articles by Professor Harald A.T.O. Reiche in *The Transactions of the American Geophysical Union*, a book, *Theodor Mommsen*, and in a collection entitled *The End of Mankind in Western Imagination*.

Professor Rotberg published several articles in *Foreign Policy, Orbis, Reviews in American History*, and in a volume entitled *The American People and South Africa: Publics, Elites, and Policy-Making Processes*. He also served as coeditor of *Climate and History: Studies in Interdisciplinary History* and *Marriage and Fertility: Studies in Interdisciplinary History*. The year saw the appearance of Professor Brinkley's book *Voices of Protest: Huey Long, Father Coughlin, and the Great Depression*, which was published by Alfred A. Knopf; and of a Vintage paperback edition of Professor Maier's *The Old Revolutionaries: Political Lives in the Age of Samuel Adams*.

MIT historians have remained prominent in the publication of scholarly journals. Professor Rotberg continues to edit *The Journal of Interdisciplinary History*, and members of the Section serve on the editorial boards of *Reviews in American History, The American Historical Review, The Psychohistory Review*, the *Journal of Family History*, the *International Journal of African Historical Studies*, and the *Journal of Interdisciplinary History*. Professor Perdue is, moreover, associate editor with Professor Phillip A. Kuhn of Harvard, of a new journal, "Chinese History and Society," which is scheduled to appear in 1983.

The Section is also represented on a wide range of professional committees and commissions. It should be particularly noted that Professor Rotberg has been elected to the Council of the American Historical Association. Last fall Professor Maier ended a three-year elected term on the executive board of the Organization of American Historians, and began another three-year term as a council member for the Institute of Early American History and Culture. She also has been nominated for the nominating board of the American Historical Association. Meanwhile, Professor Mazlish remains an officer of the International Society for Political Psychology.

The Section also has contributed to the committees and other service functions of the Department and the Institute at large. Members have headed the Departmental committee on special topics, and served as Departmental coordinator for the Undergraduate Research Opportunities Program. They have served on the tenure committees for faculty in the Writing Program and the Literature Section. They have served as freshman and pre-med advisors, and on the Committee on International Institutional Commitments.

The Section's annual History Workshop this year took as its theme "The Irrational in History." During the fall term three sessions were held. David James Fisher of the University of Southern California spoke on October 23 on "Reading Freud's 'Civilization and Its Discontents'"; on November 23 Ralph Buultjens of The New School for Social Research gave a presentation on "The Hero Myth in Contemporary History," and on December 7 Ali Banuazizi of Boston College and the Harvard Center for Middle Eastern Studies talked "On the Politics of Interpreting the Iranian Revolution." During the spring term two further sessions were held. On April 26 Stephen Oates of the University of Massachusetts at Amherst, spoke on "The Two Selves of Martin Luther King," and on May 5 Simon Schama of Harvard talked about "Guilt and Panic in a Humanistic Society."

During the fall of 1981 while Professor Maier was on sabbatical leave, Professor David Ralston served as acting Section Head. He has kindly consented to reassume that office in the spring of 1983 while she is at Yale.

PAULINE MAIER

LITERATURE SECTION

The Literature Section contrives to offer a three-tiered curriculum, comprising introductory, intermediate, and advanced subjects in 10 fields of concentration, excluding drama. This curriculum has a double intent. First, it aims to meet the interests of the general student who may be drawn to literary study only once or twice in his or her career at the Institute. Second, it provides a rich program of study for students majoring or concentrating in Literature. To an extent unusual in an undergraduate program, the curriculum lays emphasis on interdisciplinary approaches to literary study, and on theoretical, generic, and thematic subjects that range widely across geographical, linguistic, and historical boundaries. The curriculum at present remains the only occasion for students at MIT to experience a cumulative course of study in a humanistic intellectual discipline.

Institute and Sectional Activities

In connection with its introductory subjects in film, the Section affords a sequence of public showings of film masterpieces. During the fall semester, it offered a Tuesday evening series of public lectures on Shakespeare, given weekly by various members of the Section. In this connection, the Section sponsored a lecture by James Earl Jones, who played the title role in a recent Broadway production of Othello. As an offshoot of its subject in Science Fiction, it sponsored a visit and public lecture by noted author Isaac Asimov, and mounted and ran a special multi-institutional conference on Literature and Film, convened and chaired by Professor Alvin Kibel.

Professor Stephen Tapscott devised a new subject in advanced writing for Literature students, which was correlated with the Department's Distinguished Poets Series; his seminar on contemporary poets takes as its syllabus the works of poets who visit MIT to read their work that term. This past year the format of this subject made it the only one of its kind in the country; it has since been adopted as the model for similar seminars at other universities, notably Princeton and the University of Iowa.

Publications

Professor Albert R. Gurney, Jr. has had two productions of his plays running concurrently off-Broadway in New York City, to great commercial and popular success. One of these, *The Dining Room*, has been the subject of feature articles in *Time*, *Newsweek*, *The New Yorker*, the *New York Times*, and elsewhere, and has been chosen for presentation this season at the Kennedy Center for the Arts in Washington, DC. A volume of Professor Barry Spacks's poetry, "New and Selected Poems," will be published by Johns Hopkins in August; he has published poetry this year in *Poetry Magazine*, *Cumberland Poetry Review* and *Sewanee Review*. Professor Cynthia Griffin Wolff is engaged in a book-length study of the American poet Emily Dickinson and published one chapter from this work in the *Harvard Review*. Professor Kibel has embarked on a theoretical study of narrative in history and fiction; a by-product of this work has just appeared in the interdisciplinary journal *History and Theory*, and another essay is soon to appear in book publication in a volume entitled *Canons, Conventions and Criticism*. Professor David Thorburn's seminal essay on "Television Melodrama" continued to exert influence by being twice reprinted in this past year in anthologies, published by Oxford University Press and Praeger Publishers. Professor David Halperin's book, "Before Pastoral," will appear later in 1982 under the imprint of Yale University Press; he also has published two articles in *Classical Journal* and, to show that he is not merely a classicist, a third article in a series on the exiled Russian writer Alexander Solzhenitsyn. Professor Tapscott continued his work in poetry and criticism, with poems appearing in *The American Poetry Review*, *Antaeus*, and *The Paris Review*, and criticism (an article on Marcel Proust) in *Yale Review*. Professor Ruth Perry published an essay on Mary Astell in *Antioch Review* and an essay on Pope in the *British Journal of Eighteenth Century Studies*; she also completed the introduction to an anthology, "Mothering the Mind," to be published by Georgia State University Press. A monograph by Professor Peter Donaldson on Machiavelli and Cardinal Pole will be published in 1982 as part of a Festschrift for A.G. Dickens. Visiting Professor Ellen Cronan Rose's book, *Margaret Drabble: Equivocal Figures*, was published in both England and America.

Finally, the completion of book-length manuscripts are occasions worth marking. Two were completed and duly submitted to university presses this past year by Professors Susan Dickman and William Paul -- the first on Julian of Norwich and Margery Kempe, the second on the films of Ernst Lubitsch. The span of time and the range of interests involved are indicative of the breadth of scholarship in the section. In addition, Professor Tapscott completed work on his second volume of poems, "Another Body."

Scholarly Activities, Papers and Conferences

Professor Irene Tayler convened this past year's meeting of the English Institute as chair of the supervising committee of this organization, the most pretigious national organization of scholars of English and American literature. Professor Dickman chaired a session on Margery Kempe at the 1982 Modern Language Association annual meeting and was invited to deliver a paper on the same subject at Stiftlilienfeld, Austria. Professor Wolff continues on the executive board of the American Council of Learned Societies, the editorial board of the *American Quarterly*, and the editorial board of the *American Literary Heritage* -- a Federally sponsored program for

publishing definitive editions of the collected works of American authors to rival the Pleiade edition of French authors. Professor Kibel remains a member of the national board of consultants of the National Endowment of the Humanities, the editorial board of the *Nuclear Almanac*, and the planning board of *Partisan Review*. He is the director of the Cambridge Humanities Seminar, the president of the board of trustees of the University Film Studies Center, and has been appointed consultant to the Alfred J. Sloan Foundation. This past year he gave papers at the American Academy of Arts and Sciences and the Cambridge Humanities Seminar and was invited to speak on film at the Institute of Contemporary Art in Boston.

Professor Paul spoke on the films of Hitchcock at Wesleyan University. Professor Halperin has been invited to give six scholarly papers, most of them in connection with his work on Plato. He addressed the general session of the American Philological Association, the Women's Classical Caucus, and audiences at the University of Tennessee and Skidmore College, among others. Professor Louis Kampf is on the editorial boards of *Signs*, *The Radical Teacher*, and the Margery Latimer series. Professor Amy Lang addressed a session at the MLA annual meeting, the American Antiquarian Society and a colloquium on Legal Studies at Brandeis University. Professor Donaldson addressed sessions at the Modern Language Association's annual meeting, the American Association of University Professors in Italian, and the Greater Boston Reformation Colloquium. Professor Perry was program chair for the fifth annual meeting of the Northeast American Society for 18th-Century Studies, which was held at MIT this past year.

Distinctions and Honors

Professor Donaldson was awarded a research grant from the American Council of Learned Societies, and another grant from this organization went to Professor Lang. It should be noted that these grants are both highly prestigious and rare; it is most unusual for two to be awarded to the same institution, much less the same department. Professor Tapscott is currently a finalist for a fellowship at the American Academy in Rome, a Pushcart Prize for distinguished poetry in 1981, and a National Poetry Series Award. Professor Halperin was awarded the highest honor that can be awarded to a classicist of his age, the Prix de Rome in Classical Studies; he remains a Fellow of the American Academy in Rome.

ALVIN C. KIBEL

MUSIC SECTION

Curriculum, Staff Additions

Our report begins with innovations in curriculum. This year we revamped our approach to the teaching of music theory, restructuring the use of the piano lab personnel and adding a sight-singing choir, which will seek to improve hearing skills for students in the elements of music courses and in the first two semesters of writing and analysis. The choir will be led by John Oliver, conductor of the MIT Choral Society and senior lecturer in Music. This continues a reform of our curriculum begun two years ago, a reform which has resulted in greater clarity for the students and greater sense of purpose for the faculty.

One course has been added to our program for next year, 21.612 Basic Musicianship, a new approach to the elements of music which is rooted in performance, and hopes to draw performers as students. We have long been concerned that many undergraduates in our performing ensembles don't take our courses, and this course is part of an effort to bring them in. It was designed by Professor Jane Coppock, with assistance from Melissa Howe and Professor Jeanne Bamberger.

21.607 Jazz and 21.608 American Music were approved as Humanities Distribution courses as part of our long-range effort to develop the non-classical side of our offerings which will eventually result in our return to some activity in World Music as well.

After a most enlightening and resourceful search, the first in our section to culminate in live auditions for the finalists, James David Christie was chosen as Institute Organist. The members

of the search committee, Professor John Harbison, Mr. Oliver, and Professor Marcus Thompson, agreed on Christie's extraordinary professional qualities, and his performance since January has vindicated our hopes. In addition to playing at his expected high level, he has given valuable advice on the harpsichord and organ holdings at the Institute, and is in the process of reorganizing and rehabilitating them.

Two new instructors joined the staff in 1981-82, Roland Vazquez and Martin Marks, with special responsibilities in 21.60 Introduction to Music. Both were evaluated and their contracts extended. Their very divergent and complementary approaches have added much teaching strength to the course, and enthusiasm for contract extension was widespread in both cases.

Claudia Von Canon, long associated with the same course and director of the Piano Lab, was also reviewed, and has been offered a lectureship in the Section. Greater stability for this fine teacher was long overdue.

New Programs and Initiatives

Two student awards were conferred for the first time. Through the generosity of Ragnar Naess and the Council for the Arts at MIT we were able to recognize six undergraduates for outstanding performance as instrumentalists, the prize money to be applied by the students to the study of their instruments. The winners were: Jeremy Grace, Stephanie Wingfield, Jonathan Friedman, Ray Nagem, Lisa Washington, and Elizabeth Hanson. These Ragnar Naess Fellowships enable us to draw attention to an aspect of our program which we have long felt requires greater emphasis.

The first Arthur Hsu prize in composition was awarded to John Stautner. Both of the new awards were decided by faculty committees. Candidates were nominated by faculty members and invited to apply; virtually all those nominated applied enthusiastically, their letters reflecting the importance such opportunities for recognition can have in our program.

We began an experiment in governance, the one-year rotating Section head chair, which we feel is especially suited to our discipline and professional lives. Professor Harbison served through 1981-82, to be succeeded by Professor David Epstein, and eventually by the whole tenured staff. Not only is a Section full of ex-chairmen felt to be a desirable goal in itself, but the present format gives greater initiative and authority to the Section's administrative secretary, a situation we have advocated for some time.

The 1981-82 year saw the introduction of the Faculty Forum, an opportunity for members of our staff to share recent research (students and the community at large are also invited). Professors Epstein, Coppock and Timothy Aarset were the first to offer presentations.

Institute and Section Activities

Professor Aarset continued to lead the MIT Early Music Society, and was an advisor to majors and concentrators in the second term. Professor Bamberger represented us on the Humanities Curriculum Committee and led the Introduction to Music course. She also served on the Committee on Student Affairs. Professor John Buttrick supervised the Piano Committee, which oversaw sale of two instruments and, in cooperation with technician Kathleen Allen, revamped the maintenance program. He also served on the string coach and Institute organist search committees. Lecturer Edward Cohen and Professor Coppock spearheaded the effort to restructure the theory program described earlier. Professor Lowell Lindgren continued as concentration advisor (first term) and was a prime advisor to music librarian Linda Solow. Mr. Marks provided a "core" list to the Music Library for the development of our popular music collection and supervised its implementation. Mr. Oliver, in addition to his duties with the Choral Society, has been active on search committees, and was part of the group which developed the plan for classroom renovation, chaired by Professor Buttrick. Professor Thompson chaired our Concert Committee, and served on search committees. Professor Barry Vercoe continued to exert great influence on curriculum development as chairman of that committee, in addition to his work at the Experimental Studio. Professor David Epstein, on leave second term, chaired the committee on Mr. Cohen's proposed promotion to senior lecturer, the result of which is not yet in.

Publications

Professor Aarset published an edition of *Instrumental Ensemble Music in Petrucci Prints 1501-1504*. Professor Bamberger published four papers dealing with computer use for study of the musical learning experience. Professor Coppock's "Conversation with Arthur Berger" appeared in the *Partisan Review*. Professor Vercoe's "New Dimensions in Computer Music" was the lead article in *Trends and Perspectives of Signal Processing*, April 1982. Ms. Von Canon's second novel "The Inheritance" will be published in July 1982. Perhaps the most prolific, at least in published form, was Professor Lindgren, with six articles, all in prominent journals, and a two-hundred-page chapter on the baroque in the *Schirmer History of Music*.

Distinctions and Honors

Professor Aarset was awarded the 1981 Noah Greenberg Award from the American Musicological Society. Professor Coppock has been commissioned to do articles for the San Francisco Symphony Program Guide and Tempo. Professor Bamberger has been employed by the University of Tel Aviv as a consultant to the schools of music and education. Professor Buttrick began a project to record all the Beethoven piano sonatas. He continues to perform at major centers, including the Salzburg Festival, and the Bavarian Music Festival. Mr. Cohen is working on a piece for horn and piano, commissioned by MIT affiliate artist Jean Rife. Mr. Oliver's Tanglewood Festival Chorus received a Grammy Award for *Gurrelieder*. The chorus is featured in two new Boston Symphony recordings -- the Mahler 8th Symphony, and a John Williams Boston Pops record. The MIT Symphony, under Professor Epstein, produced two new recordings for EMI Records. Professor Epstein was awarded a second fellowship at the Max Planck Institute, Munich, to pursue his studies of musical time. While in Europe he also fulfilled conducting engagements, among them concerts with the Orchestre Nationale de Paris and l'Orchestre de la Suisse Romande. Professor Thompson, in addition to commissioning new works for viola, has performed with the Chamber Music Society of Lincoln Center, at the Anchorage Bach Festival, at the Harlem School of the Arts, and will be visiting professor at the Eastman School of Music next year. Professor Vercoe was awarded a Guggenheim Fellowship, which he will use for a residence at l'Institut du Recherche et Coordination Acoustique/Musique in Paris. His Experimental Studio received a large grant from the System Development Foundation to be applied to studio personnel and hardware over the next three years. Professor Harbison was named Exxon-Rockefeller Composer-in-Residence for the Pittsburgh Symphony. He has been commissioned by the San Francisco Symphony for their 90th anniversary, and by the New Haven Symphony for their 75th anniversary. The San Francisco Opera gave the first West Coast performance of his opera *Full Moon in March* in April 1982.

Concerts at MIT

Many significant concerts occurred on the MIT campus in 1981-82; during the second term attendance at these concerts was at a notably high level due to our new Concert Coordinator, Elizabeth Brockman. Among the many noteworthy events were faculty recitals by Professors Thompson and Buttrick; the annual concert by students from Professor Vercoe's studio; and concerts by the brass ensemble and the concert band, which included works by students in Professor Harbison's composition seminar.

The highlight of the Choral Society's season was Schumann's *Faust*, the first Boston performance of this piece in 15 years. The MIT Symphony presented a convincing revival of Persichetti's *Piano Concerto*. The winter concert of the MIT Chamber Players included the premiere of Mr. Cohen's *Three Songs*. For the first time, all members of the Piano Lab staff gave Kresge recitals. A distinguished Guest Artist's Series presented New York City Opera soprano Faith Esham, the Concord Quartet, the Emmanuel Quintet (with recent works by Harbison and Lerdahl), and the Primavera String Quartet. The Abramowitz series presented, for the second year, a survey of Boston Jazz.

JOHN HARBISON

WRITING PROGRAM

This was a year of stability and innovation for the Writing Program. Most curricular programs continued as before, but a new Writing Center was opened and discussions of the new Institute Writing Requirement led to reevaluation of current course offerings, which were perceived to be suitable for the needs of most MIT students but open to modification in response to a potential new constituency of students seeking to fulfill the requirement.

Raw enrollment figures, as well as the number of students choosing to concentrate and major in writing, continued strong. The effect of the new concentration and major requirements, redesigned in 1980-81, which require concentrators and majors to select one of the Writing Program's three main branches -- creative writing, essay writing, and science and technical writing -- as their main area of interest, became apparent in two ways. Students' programs became more structured and compact, and there was heightened interest in the advanced level of the writing curriculum. One new subject was added at this level -- Writing Longer Fiction, developed and taught by Lecturer Ilona Karmel; it joined the Advanced Poetry Workshop, Advanced Fiction Workshop, Naturalist Writing, Advanced Essay Workshop, Advanced Workshop in Scientific and Engineering Writing, and the Science Writing Internship.

As usual the Writing Program also served students with less sustained, if equally intense, interest in writing. In addition to its introductory and intermediate level subject offerings, the Writing Program opened a Writing Center at the beginning of the spring term. Located on the third floor of Building 14, the Center was funded jointly by the Writing Program and the Office of the Provost. It was directed by Lecturer Steven Strang, who had been working on planning with other Writing Program faculty members for over a year. The Center was open to all MIT students on both a walk-in or an appointment basis. It offered individual instruction, either by Lecturer Strang or by one of the four tutors whom he had trained during the Independent Activities Period, on a variety of writing problems, from how to punctuate to how to organize to how to argue. Students who chose to use the Writing Center took advantage of the entire range. Some learned how to write coherent sentences; others explored subtle issues of word choice and tone. Users included both undergraduate and graduate students, and both native speakers and those for whom English is the second language.

Although planning for the Writing Center began before the Committee on Educational Policy had begun to discuss the possibility of an undergraduate writing requirement, the Center will clearly be an important element in the Institute's newly inaugurated effort to raise the level of undergraduate writing. In addition, the Writing Requirement will probably produce increased demand for the services of the Center. Because the precise form of the Writing Requirement has not been made clear at this writing, it is not yet possible to specify in what other ways the Writing Program will contribute to its implementation. A new subject, tentatively entitled Sentences and Paragraphs, is currently in the planning stage.

The offerings listed in the catalogue represent only a part of the Writing Program's curriculum. A great deal of its teaching happens outside the Humanities Department curriculum. Professor JoAnne Yates directs an active program of business writing instruction for master's degree students at the Sloan School of Management. In his capacity of Director of Technical Communication, Professor James Paradis coordinates the extensive technical writing cooperative program in the School of Engineering. All the engineering departments currently offer cooperative writing instruction at the undergraduate level, and a majority at the graduate level. Planning is under way for new graduate programs in the Departments of Electrical Engineering and Chemical Engineering. Teaching with Professor Paradis in the cooperative programs are Professor David Dobrin and Lecturers Charles Sides and Ilze Levis. In addition to designing new curricula, this group constantly revises old ones. This year, the undergraduate program in Materials Science was restructured. In addition, Professors Paradis and Dobrin began an extended study of writing practices in a national chemical engineering industry. The results of this study will enrich graduate instruction in technical communication at MIT. The Writing Program also works with the School of Science and the School of Architecture and Planning to offer cooperative writing instruction for graduate students.

In addition to its academic-year programs, the Writing Program offers a weeklong summer workshop on "Communicating Technical Information." Directed by Professor Paradis and staffed primarily by present and former members of the technical writing staff, the workshop is now in its 26th year. It attracts engineers, scientists, and managers from across the US and, this year, from England, Israel, India, and Nigeria.

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 Voigt's poems appeared in the *New Yorker, The Nation, Poetry Magazine, Ploughshares, Antaeus,* and the *Georgia Review*. Lecturer Fanny Howe's *Yeah, But*, the second of a trilogy of novels for young adults, was published by Avon Books; one of her stories was included in *The Best Stories of Ms. Magazine*. Alice James Press published *Backtalk*, a collection of poetry by Lecturer Robin Becker. Lecturer Frank Conroy contributed reviews to *Esquire* and the *Partisan Review*. Lecturer Strang was a regular book reviewer for the *Providence Journal,* and Lecturer Marilyn Richardson's article on "Barbara Chase-Riboud" appeared in the *Dictionary of Literary Biography*.

Professor Thomas Postlewait's article about Pinter and Ibsen appeared in *Comparative Drama*; he also contributed reviews to the *Theatre Journal*. Professor William Bennett was coauthor with Joel Gurin of *The Dieter's Dilemma: Eating Less and Weighing More,* published by Basic Books. Excerpts appeared in *Science 82, Harvard Magazine,* and *American Health*. He also published reviews in *The Washington Post, The Sciences,* and *Technology Review,* as well as writing for *Harvard Magazine* and *The Harvard Medical School Health Letter*. Professor Bernard Avishai wrote on the Middle East for the *New York Review of Books*. Professor Harriet Ritvo's "Gothic Revival Architecture in England and America: A Case Study in Public Symbolism" appeared in *Allegory, Myth and Symbol* (Harvard University Press).

Professor Barbara Gastel wrote on Women's health issues for *Women's World*; she also contributed to the *New England Journal of Medicine* and the *Year Book of Health and Medicine*. Professor Rae Goodell's review of books about DNA appeared in *The Washington Post*; Professor Dobrin discussed technical writing in *College English* and *New Directions in Technical Communication*. The latter volume also includes Professor Paradis's essay on early language reform in the sciences. In addition, Professor Paradis reviewed books on the history of natural history for the *London Review of Books*. Lecturer Sides contributed articles on technical writing pedagogy to the *American Business Communication Journal,* the *Journal of Technical Writing and Communication* and the *Technical Communication Casebook*.

In addition to their published work, many members of the Writing Program gave public readings or delivered papers at professional meetings. Professor Elzbieta Chodakowska lectured at Regis College. Professor Bennett spoke at the Harvard Medical School on cigarette use, at the Massachusetts General Hospital on appetite controls, and at the annual meeting of the American Association for the Advancement of Science on science journalism. Professor Paradis was part of a panel on "Technical Communication and Industry" at the Association of Departments of English. He also spoke, as did Professor Dobrin and Lecturer Sides, at the Conference on College Composition and Communication. Professor Dobrin also gave papers at the Modern Language Association and the International Technical Communication Conference, and Lecturer Sides at the National Council of Teachers of English and the International Technical Communication Conference.

Lecturer Becker gave several local readings of her poetry; Lecturer Howe read in Boston and New York; and Professor Voigt in Dallas, Richmond, Atlanta, and Swannanoa, NC. Professor Yates participated in a panel on "Teaching Communication Channels" at the American Business Communication Association. Professor Avishai spoke on Terrorism at Colorado College and on secular Judaism at the Jewish Studies Center of the City College of New York Graduate Center. Professor Gastel presented a paper on the development of hemodialysis to the American Association for the History of Medicine; Professor Ritvo spoke on "Victorian Rabies" to the Midwestern Historians of Medicine.

Many faculty members performed professional service outside of MIT. Professor Paradis served on the editorial Board of the *Nuclear Almanac*; Professor Avishai was a contributing editor of *Dissent* and *Moment*; Professor Gastel was assistant editor of the *Johns Hopkins Medical Journal*. Lecturer Conroy was special fiction editor for *Delacorte*. Professor Bennett served as associate editor of the *Harvard Medical School Health Letter* and president of *Harvard Magazine*, and as a member of the steering committee for the American Chemical Society's new textbook of chemistry. Professor Chodakowska served on the board of trustees of *Parents' Choice*; Lecturer Becker on the board of the Cummington School for the Arts.

In January, Lecturer Conroy became the head of the Literature Section of the National Endowment for the Arts. While he is serving the national community of writers in this position, he will continue to teach his weekly workshop course in the Writing Program. Professor Goodell also

was active at a national level, serving on the Council of the Society for Social Studies of Science, the executive committee of the National Association of Science Writers and the Committee on Public Understanding of Science of the American Association for the Advancement of Science. Lecturer Richardson was a member of the Literature Panel of the Massachusetts Council on the Arts and Humanities; Professor Voigt was a panelist for the Vermont Council for the Arts.

Professors Avishai, Dobrin, Ritvo, and Yates were awarded Old Dominion fellowships for research and writing. In addition, Professor Dobrin was selected to participate in a National Endowment for the Humanities summer seminar on Foucault and Heidegger.

The Writing Program's curricular links to other Schools in the Institute were reinforced by other faculty activities. Professor Goodell served on the Committee on Faculty-Administration and Professor Ritvo on the Committee on the Humanities, Arts, and Social Sciences Requirement. Program faculty gave a variety of Independent Activities Period offerings; several served as freshman advisors or read admissions folders. As in previous years, the Writing Program sponsored a series of readings. Speakers included V.S. Naipaul, Francine Prose, Derek Walcott, Mary Helen Washington, Bernadette Mayer, and Lewis Warsch. These readings present distinguished authors to the MIT community as a whole; they also offer a range of models for writing students. The Writing Program sponsors a series of prizes for undergraduate writers, which similarly provides an occasion for them to think of themselves as serious writers. In addition, the Program has begun to work closely with *Rune*, the primary outlet for MIT student writing.

Having filled several vacancies last year, the Writing Program conducted three searches late in the year, all for visiting positions to fill vacancies created by leaves of absence.

The faculty of the Writing Program is looking forward to another year of organizational stability in which to devise and develop appropriate supportive facilities for the newly introduced Writing Requirement.

WILLIAM BENNETT
HARRIET RITVO

COURSE XXI

Humanities and Engineering	XXI-A
Humanities and Science	XXI-B, 1
Humanities and Science	XXI-B, 2

For Course XXI this has been a felicitous and productive year marked by important curricular innovations, structural changes, and unusually impressive achievements by students majoring in Humanities.

The office continues its multifaceted job of administering major programs, stimulating needed changes in existing curricula and prompting educational innovation, and sponsoring and nurturing interdisciplinary ventures of several types.

Students: Numbers and Quality

The May 1982 census shows 73 declared majors in Course XXI, the highest figure since 1972-73. This population tends to cluster itself most heavily in Writing (22), Literary study (20 in Literature and Foreign Languages and Literatures combined), and Option Two, the integrative version of the joint major combining Humanities and Engineering/Science (16). The Anthropology/Archaeology, History, and Music sections continue to enroll a scattering of majors, as do the interdisciplinary programs in American Studies and Russian Studies and the custom-made courses of study under the heading of Major Departures.

One clear shift worth notice is the resurgence in popularity of the joint major programs. For many years the students in these programs had been conspicuously outnumbered by those pursuing

the full major, but at present there are 47 "joints" to 26 "fulls." The reversal has been rather sudden. Only three years ago there were just 17 "joints" and 43 "fulls." This change may be partly attributable to the appeal of the Option Two version of the joint program, which is entering its fourth year. Another factor, most probably, is the state of the economy and the job market, which encourages many XXI majors to extend their scientific/engineering education in the interest of becoming employable.

Course XXI majors continue to hold their own, qualitatively, with students majoring in other disciplines. Their cumulative academic ratings remain respectably high, the incidence of Committee on Academic Performance actions (warnings, withdrawals) reassuringly low. Another measure not only of their success but also of their variety may be found in a survey of their plans for next year.

There has been a considerable increase in the number of XXI graduates going on for higher academic degrees. In medicine, one student will begin work toward the M.D. at SUNY at Buffalo, and another has been accepted at the US Uniformed Health Services University. A pre-law student has the luxury of deciding among the Universities of Pennsylvania and Michigan, Cornell and NYU. One of our literature majors will enter the Ph.D. program in English at Princeton, having also been admitted at Berkeley, Brown, and the Universities of Chicago and Minnesota, while a promising playwright will enter the M.F.A. program at either Catholic University or UCLA. An Option Two major who combined writing with psychology has been admitted to the Harvard School of Education. Our sole Anthropology/Archaeology major will enter a two-year master's program in medieval history at the University of Wisconsin.

We have strong displays of enterprise in the Science/Engineering side as well, with graduates moving on to graduate study in Chemical Engineering and Physics (both at MIT). Another chose Berkeley over Princeton and Johns Hopkins for a Ph.D. in Physical Chemistry. Two of our people will be attending MIT's Sloan School. One will continue work toward a second MIT S.B. in Physics.

Two will receive military commissions, one in the Navy, the other in the Air Force. A writing major will pursue a career in technical writing at Hewlett-Packard.

Course XXI Degrees and Honors in 1982

Two students received the S.B. in February and 17 in June. Several others are expected to complete requirements by September.

This has been an exceptionally impressive year for honors, awards, and distinctions among our students. Laura Gooch, in Literature, and Steven Snider, in Russian Studies, were elected to Phi Beta Kappa.

For the first time in the eight-year history of the competition, both of the I. Austin Kelly III Prizes for excellence in humanistic scholarship were won by Course XXI majors, Michael Colvin and Roslyn Romanowski of the Class of 1982.

The Boit Writing Prizes for Poetry were swept by Marissa Martinez, Irene Baker, Peter Cerrato, and Howard Kolodny, all of the Class of 1983, while one of the Boit Fiction awards went to Bill Bryant Class of 1983 and an Engineering Writing Prize to Stanley Anderson Class of 1982.

Harry Newman Class of 1983 distinguished himself by winning both the Boit Manuscript Prize for extended creative work in progress and the Laya and Jerome B. Wiesner Award for his founding and leadership of the Environmental Theatre group.

Redeployment and Strengthening of Degree Programs

With the support and encouragement of Department Head Peter H. Smith, and some creative participation by the Institute Committee on Curricula, it was possible to achieve a much-needed restructuring of the "map" of Course XXI. The perplexing array of programs and alternate programs, options, and suboptions, produced over the years through a lengthy process of historical accretion, will be replaced by a far simpler scheme effective July 1982. The full humanities major (hitherto XXI-B, Program 2) becomes simply XXI. The joint major with Engineering (hitherto

XXI-A) becomes XXI-E. The joint major with Science (hitherto XXI-B, Program 1) becomes XXI-S. The distinction between Options One and Two, under the joint major, is eliminated, with Option Two reappearing as Humanities/STS, one of several humanistic fields available in XXI-E and XXI-S.

In another somewhat overdue effort, a closer balance was achieved between the Humanities and Engineering/Science components in the joint programs by increasing the number of required subjects on the Engineering/Science side from four to six. For students who are able to take the Institute Laboratory Requirement subject and one Science Distribution subject in the same field, the total is effectively increased to eight subjects, a substantial educational experience which matches in weight the seven subjects plus thesis required on the Humanities side.

Finally, with the assistance of Professors Stephan Chorover and Richard Held of the Department of Psychology, there was an extensive redefinition of requirements for Psychology as the Science component in XXI-S (formerly XXI-B,1).

New Programs

Collaborative planning by faculty from the Humanities Department and the Program in Science, Technology, and Society (STS) produced a new full XXI major, under the heading Humanities/STS, which combines subjects from the curricula of STS, the Humanities Department, and other fields as appropriate, to enhance historical understanding of the socio/cultural role and influence of technology and science. This full major is unique in that it may be pursued only in conjunction with another full degree program in Engineering or Science, as part of a double-degree arrangement. Although there are minor differences in emphasis, this double-degree program in effect aims on a larger scale at the same educational goals as those of the single joint degree in Humanities/STS (formerly Option Two). Both of these programs will be supervised by a committee drawing its membership from the Humanities Department, STS, and the Schools of Engineering and Science.

Another addition -- in this case to the array of humanities fields available for the joint major -- is Latin American Studies. Although the number of subjects available for this major is modest at present -- as it is in Russian Studies -- there is clearly enough strength and variety in the curricular offering to warrant this addition to the fields available in area studies.

Concentrations

The Course XXI Office coordinated the publication of the Humanities, Arts, and Social Sciences concentration specifications in 16 fields, the selection and scheduling for field advisors, and the keeping of records on the numbers of students concentrating in each field.

Option Two Seminar

The collaborative seminar, 21.901-.902J, for joint majors in the Option Two program, was taught this year by Professors Kenneth Manning of STS and Alvin Kibel of Humanities. Henceforth this seminar will also be required for students pursuing the Humanities/STS double-degree program.

Informational and Social Events

As in the past, Course XXI organized the Department's participation in the Academic Midway in September and the Humanities Open House in April. For pleasure and conviviality there was a holiday party in December and the Commencement breakfast in June.

Lounge Relocation

The Henry Greenleaf Pearson Humanities Student Lounge (14N-309) fell victim to the need for more faculty office space. A new Pearson Lounge has been established in 14N-435, formerly the Music Lounge.

Administration

Professor Travis Merritt served as director of Course XXI. Professor Louis L. Bucciarelli, co-director since 1974, officially resigned from that position in order to devote his energies more fully to teaching and research. He will continue to work closely with Course XXI, however, as a member of the STS faculty.

Virginia M. Sorenson completed her third year as administrative assistant for Course XXI. Her consistently crucial service to the office cannot be overstated.

TRAVIS ROE MERRITT

Department of Linguistics and Philosophy

One of the major faculty initiatives taken in the Department during the academic year 1981-82 was the continuation of its search for a position in linguistic theory and natural language semantics. This search was successfully concluded with the appointment of Professor James Higginbotham, who has been a visiting associate professor in the Department of Linguistics and Philosophy for the past two years, filling a position which had remained vacant since the spring of 1975. Professor Higginbotham will play an important role in bringing together the intellectual programs of linguistics and philosophy where they overlap in the important areas of natural language semantics. This is a major milestone in the development of this Department and unique in the country in that it houses both linguistics and philosophy graduate programs.

During the spring, the Department sponsored a colloquium which was carried on in parallel with the above search. This colloquium brought several distinguished linguists and philosophers to MIT as guest lecturers. These visitors were Professors Irene Heim, Center for Cognitive Science, Stanford University; Nathan Salmon, Princeton University; Manfred Bierwisch, Zentralinstitut für Sprachwissenschaft, East Germany; Hans Kamp, University College, London; and Stanley Peters, Center for Advanced Study in the Behavioral Sciences.

The Departmental move from its offices on the second floor of Building 20, to the third floor of that building was completed in January. The new offices constitute a welcome change for the Department, not only because of their physical attractiveness, but because it now brings all the members of the Department and personnel associated with the Center for Cognitive Science into a single geographical area.

With the close of academic year 1981-82, Professor George Boolos concluded two years of service as chairman of the philosophy program. On behalf of the students and faculty of the Department, I would like to thank Professor Boolos for his efforts. I would also like to announce that Professor Jerry Fodor will assume the duties of philosophy chairman beginning July 1, 1982.

During the fall term we were pleased to have Professor Tyler Burge of the University of California at Los Angeles as visiting professor in the philosophy program. Professor Burge taught an undergraduate subject, Philosophy of Mind and Psychology and a graduate subject, Reference. He took an active part in both informal and formal colloquia, and his visit to the Department was extremely beneficial.

RESEARCH

Linguistics

Professor Joan Bresnan has continued research on lexical-functional grammar. She has worked intensively on the theory of anaphora and control and its application to "exotic" language phenomena. Among the articles resulting from her research are: "An Approach to Universal Grammar and the Mental Representation of Language," *Cognition* X (1981), pp. 39-52; and, with J. Simpson,

"Control and Obviation in Warlpiri," a paper presented at the first annual West Coast Conference on Formal Linguistics, Stanford University, in January 1982, which will also appear in the Proceedings.

Institute Professor Noam Chomsky's publications included: "A Naturalistic Approach to Language and Cognition," *Cognitive and Brain Theory*, winter 1981; "Principles and Parameters in Syntactic Theory," in N. Hornstein and D. Lightfoot, eds., *Explanation in Linguistics*, Longman, 1981; "On the Representation of Form and Function," *Linguistic Review* 1, 1981; "A Note on Non-Control PRO," *Journal of Linguistic Research*, 1.4, 1981; and "Markedness and Core Grammar," in A. Gelletti, L. Brandi, L. Rizzi, eds., *Theory of Markedness in Generative Grammar*, Pisa, 1981. Finally, Professor Chomsky has completed a monograph to be published by MIT Press entitled "Some Concepts and Consequences of the Theory of Government and Binding." This monograph develops notions contained in the final chapter of his book *Lectures on Government and Binding* published in 1981 and constitutes a radical simplification of the theory presented there. The major thrust of this work is toward the development of a theory of universal grammar in terms of a system of subtheories based on principles that permit parametric variation. The grammar of a particular language, when viewed in this fashion, is essntially rule-less, consisting of specifications for these parameters.

Kenneth L. Hale, Ferrari P. Ward Professor of Modern Languages and Linguistics, continued lexicographical work on several aboriginal languages of Australia, with special emphasis on Warlpiri, and with a focus on the problem of constructing entries which contain the grammatical information necessary to ensure fully grammatical use of lexical items in syntactic structures of the language. He also continued work on the grammars of so-called non-configurational languages, with special attention given to Warlpiri, Navajo, Papago, and Basque.

Institute Professor Morris Halle collaborated with Dr. Jean-Roger Vergnaud on studies in metrical and autosegmental phonology, resulting in a paper "Harmony Processes," in W. Klein and W. Levelt (eds.) *Crossing the Boundaries in Linguistics*, (Reidel, Dordrecht), pp. 1-22. A forthcoming book on problems in phonology (with G.N. Clements) is now in process with MIT Press.

Professor James W. Harris' research centered on Spanish phonology and morphology. In particular, he has completed a study of phenomena involving nasal consonants in Spanish, in the context of the nascent theory of Lexical Phonology. His article "Spanish Syllable Structure Assignment is Cyclic," was published in *Current Research in Romance Languages*, J.P. Lantolf and G.B. Stone (eds.), Indiana University Linguistics Club.

Professor Samuel Jay Keyser continued his work in the theory of the syllable. An article, coauthored with G.N. Clements of Harvard University and entitled "A Three-tiered Theory of the Syllable," was published as Occasional Paper No. 19, Center for Cognitive Science, MIT. In addition, two articles, "There is Method in their Adness: The Form of Advertisement" (*New Literary History*, forthcoming) and "Why Study Human Language?" (*Studies in Cognitive Science*, M. Gazzaniga, forthcoming), have been completed. His work with Professor Wayne O'Neil in the history of English continued, and he has completed an article coauthored with P. Kiparsky entitled "Syllable Structure in Finnish Phonology" (forthcoming, MIT Press).

Professor Paul Kiparsky's book *Explanation in Phonology* (1982) has been published by Foris, Dordrecht. The main focus of his research has been the development of the theory of lexical phonology. In this theory, the rules of word phonology apply in the lexicon to the output of each level of morphology. Sentence phonology applies after words have been put together in the syntax. The two sets of phonological rules have radically different properties which can be naturally explained within this framework.

A book translated as *English Transformational Grammar*, available in Chinese only, is based on Professor O'Neil's lectures, notes, and short essays, written by him in Beijing, China during his stay there in 1980. With Professor Keyser he has continued research on phonological and morphological change in the history of English.

Professor John Ross has been attempting to extend the notion of primacy, itself an extension of part of the Keenan-Comrie notion of accessibility, to cover a wider class of data, and to link up with his previous research on "wording up" -- that is, the affixation to verbs or adjectives of #-affixes. Within semiotics, he has attempted to deepen his understanding of the notion of verbal art, and of its connections to other art forms.

Philosophy

Imagery, an anthology edited by Professor Ned Block, was published by the MIT Press. Professor Block has been working on two papers concerned with imagery. One argues that if our mental images are genuinely pictorial representations, then many of the phenomena that seem to be in the domain of cognitive science are really in the domain of neurophysiology. The other addresses a persistent fallacy in the literature on imagery. His research also included a work on functionalism and mental representation.

Professor Boolos has published two articles: "Extremely Undecidable Sentences," *Journal of Symbolic Logic*, 46 (1981) pp. 661-662; and "For every A there is a B," *Linguistic Inquiry* 12 (1981), pp. 465-467. His ongoing research concerns the connections between systems of modal logic and various concepts of provability in formal systems, with special interest in questions regarding the possibility of extending known results to the quantificational case.

Professor Sylvain Bromberger revised his paper, "Mind, Language and Knowledge" and has recently begun a project with Professor Halle on the philosophy of phonology.

Professor Judith W. DeCew continued research in philosophy of law. In particular, she worked on a paper on privacy, arguing that recent torts and constitutional cases show there is an important privacy interest protected in constitutional law despite claims by legal scholars that only autonomy is involved. She completed an article "Brandt's New Defense of Rule Utilitarianism" which will appear in *Philosophical Studies*, and another article "The Soul in the Machine," review of Kranzberg, ed., *Ethics in an Age of Pervasive Technology*, appeared in *Technology Review* 83, 4 (1981).

Professor Fodor finished his article "Cognitive Science and the Twin-Earth Problem," (forthcoming, *Notre Dame Journal of Formal Logic*), and is completing two essays on the philosophical foundations of cognitive science. In collaboration with Drs. Lorraine Tyler and William Marslen-Wilson of the Max Planck Institute, Professor Fodor is doing work on experimental psycholinguistics.

Professor James Higginbotham's publications include "Comments on Hintikka's Paper," *Notre Dame Journal of Formal Logic*, 23 (3) (1982); and the two reviews for the *Philosophical Review*. He is revising his paper "The Logic of Perceptual Reports," which was first given at the Amherst Workshop, February 1982, and which will appear in a forthcoming volume of *The Journal of Philosophy*.

Professor Paul Horwich has been concerned with questions on "the problem of the direction of time." The project involves 1) an attempt to specify literally what it is for time to be "directed" or "anisotropic"; 2) the precise characterization of about a dozen pervasive, temporally asymmetric phenomena -- such as the fact that we can causally influence the future but not the past, and the fact that we take ourselves to know much more about the past than the future; and 3) an attempt to explain these asymmetries in a unified way and to examine their bearing upon the directedness of time itself. One article, "How to Choose Between Empirically Indistinguishable Theories" appeared in *The Journal of Philosophy*, and another "On Refutations of Skepticism" appeared in *Nous*.

Professor Thomas Kuhn has been involved in various studies of scientific change pointed towards a book tentatively titled "Philosophy of Scientific Development." He also completed an Occasional Paper for the Center for Cognitive Science entitled "What are Scientific Revolutions?"

While on an Old Dominion Fellowship in the fall term, Professor Edwin McCann continued work on his book "Locke vs. Essentialism" as well as other papers on Locke and Kant.

Professor Irving Singer has brought the sequel to his earlier book *The Nature of Love: Plato to Luther* to its final stages. The new book deals with courtly, romantic, and naturalistic concepts from the 12th through the 19th centuries. It is mainly a work in "philosophical history," concentrating upon works of philosophy and literature during the relevant periods.

Professor Judith Thomson has nearly completed her book on rights, and has completed a paper entitled "Parthood and Identity Across Time," which will appear in the *Journal of Philosophy*.

FACULTY

Professor Kiparsky received the 1981 Rishi Prize for the best book on Sanskrit. This book, entitled *Panini as a Variationist*, was co-published by the MIT Press and has been hailed as shedding important new light on Panini.

As a Council of Humanities Visiting Fellow at Princeton University, Professor Bresnan gave several lectures there in April. She also was a member of the Advisory Committee for the Division of Information Science and Technology, National Science Foundation.

Under a grant from the National Endowment for the Humanities, Professor Fodor conducted a summer institute on the Philosophy of Psychology at the University of Seattle.

Professor Halle served as a member of the visiting committee of the Department of Linguistics at Harvard University, and as a member of the Linguistic Society of America's nominating committee.

Several faculty members served as editorial consultants to publishers. These included: Professor Boolos, *Journal of Symbolic Logic*; Professor Higginbotham, *The Journal of Philosophy*; Professor Harris, Harcourt Brace Jovanovich, Inc.; Professor Bromberger, MIT Press Board; and Professor Block, Harvard University Press.

During the summer, Professor Hale spent time with the Lardil tribe, Mornington Island, Australia, where he presented his Lardil dictionary and gave literacy instruction in the Lardil language.

While on sabbatical as Visiting Fellow, Clare Hall, Cambridge University, Professor Richard Cartwright gave invited lectures at Cambridge and to the Oxford Philosophical Society.

Independent Activities Period

Members of the Philosophy faculty presented a series of lectures on major figures in the history of philosophy, including Descartes, Hume, Kant, Nietzsche, Kierkegaard, Russell, and Wittgenstein.

Linguistics faculty and students sponsored a conference on syntactic theory with participants from MIT and other universities. Linguists and philosophers also presented a joint lecture series under the general heading "Human Language, Human Thought."

Colloquia

In addition to the Semantics Colloquium mentioned earlier, the Department presented several other colloquia. Guest speakers in linguistics included: Professors John Goldsmith, Indiana University; Jill Carrier Duncan, Rutgers University; Robert Freidin, McGill University; Jonathan Kaye, Universite du Quebec; Elan Dresher, Brown University; and Steven Lapointe, Johns Hopkins University. Lecturers in philosophy were: Professors Jonathan Bennett, Syracuse University; Martha Nussbaum, Harvard University; Michael Slote, Trinity College, Dublin; and Michael Jubien, University of Massachusetts.

As usual, the Department attracted many visitors from this country and abroad. Among them were Drs. Adriana Belletti, University of Pisa; Toni Borowsky, University of Massachusetts; Jeanette DeCarrico, University of Washington; Benoit deCornulier, Commission Franco-Americaine; Hiroyuki Hattori, Aichi University of Education; Kazuko Inoue, International Christian University; Patricia Kitcher, University of Vermont; Michael Lipton, Northeastern University; Donaldo Macedo, Boston University; Robert Matthews, Rutgers University; and Karen Zagona, University of Washington.

SAMUEL JAY KEYSER

Department of Political Science

The Department's primary concern continues to be the pressure exerted on our doctoral program by economic circumstances outside our control. On the one hand, increasing costs of graduate education are outstripping the availability of research and teaching assistantships, fellowship support, and student loans. On the other hand, employment prospects for fresh Ph.D.s -- especially in the academic world -- are not so promising as to encourage prospective graduate students to embark on the long and financially difficult period of training and apprenticeship.

In some respects, we are better placed than other political science departments to deal with this situation -- in other respects worse. On the debit side is the fact that, compared with the other leading departments which are our major competitors for the very best students, we are significantly less well endowed and unable to offer substantial, multi-year fellowships. The relatively small size of our undergraduate program, moreover, means that we lack the large number of teaching assistantships on which some departments rely to support many of their graduate students. We continue to depend heavily, therefore, on faculty research projects and Federal Work-Study funds to give employment to many students. Should these sources of support decline significantly, and should the graduate student loan program be seriously curtailed, the crisis could take on serious proportions.

We are acting on the belief, however, that relevant aspects of the economy will improve and that we will remain in good health during this difficult time by capitalizing on our comparative advantage as a relatively small, research-oriented Department of high quality. One of our distinguishing features as a Department has been our ability to maintain an effective balance between the two orientations characteristic of political science as a discipline: empirical and theoretical research intended to advance the understanding of politics in relation to other human activities, and policy-oriented research designed to help citizens and government officials understand more clearly national and local problems and to suggest avenues for their resolution. Individual faculty members find themselves at different points along this spectrum -- many, indeed, move effectively from one point to another at different times in their careers -- so that as a Department we are relatively well placed to train students for a variety of possible careers. An increasing proportion of our graduates have been taking policy research and analysis positions in government, nonprofit institutions, and business. We believe that a research-oriented faculty in an environment which values intensive student-faculty interaction should be able to maintain a competitive edge even in a difficult employment market.

The Department has moved to adapt its graduate program to current needs by developing a new S.M. degree program in Political Science and Public Policy. The program will provide students with an opportunity to specialize in one of our public policy fields: 1) defense and arms control; 2) science, technology, and public policy; 3) communications policy; and 4) international development. It is intended to meet the needs both of mid-career professionals and recent college graduates interested in training for non-academic employment in government, the media, business, banking, research institutes, and nonprofit institutions where specialized training in public policy is useful. The program may also be attractive to students considering the possibility of seeking a Ph.D., but not committed to it at the outset.

The program is based on the premise that while there are many common features of the policy process, each policy area has enough distinctiveness to require specialized expertise. The policy process, for example, is quite different in the area of defense and arms control than in the field of communications policy, while the policy process in developing countries is not the same as in the United States. Moreover, policy analysis presumes not only a capacity to predict policy outcomes, but also assumes a capacity to predict outcomes in the absence of policy interventions. To do so, students must be well grounded in theories which seek to explain and understand the social and political phenomena which give rise to policy issues. We are committed to the training of policy analysts with a broad outlook. Technical and analytical skills are important, but policy analysts must also have a larger understanding of what they are doing, of the long- as well as short-term consequences of public interventions, of the unintended as well as intended consequences, and of the wider as well as the narrower effects of policies. These premises suggest some of the ways in which our program is intended to be different from the more general purpose public policy programs that have been established in other universities.

The proposed degree program was worked out during the spring by an ad hoc faculty committee chaired by Professor Myron Weiner. It will be taken up by the Committee on Graduate School Policy in the fall and, if approved in good time by the Institute faculty, will accept students for September 1983. We look upon the new master's program in Public Policy as both a distinct improvement to our existing, rather loosely focused master's program, and as a way of supplementing -- but by no means replacing -- the doctoral program that will remain at the center of our graduate training effort. It may or may not be indicative that an unusually high proportion of those accepted to the doctoral program this spring have decided to come, resulting in the largest incoming class in many years. Given all the difficulties mentioned above, this is a surprising but hopeful sign.

The undergraduate program is in good shape, holding its own with respect to enrollments, concentrations, and majors, despite the strong trend among Institute graduates as a whole toward professional training in engineering. At year's end there 40 majors, including the 14 who received the S.B. in June. (At least five of the graduates, incidentally, are going on to law school.) A source of some concern is the fact that relatively few majors have chosen the Public Policy option introduced a few years ago. This may in part be related to the difficulty we have had in finding external support for the public service internships that are a central aspect of the public policy program and, more generally, an attractive feature of the Department to students majoring in other fields. Next year will see a continuation of the fundraising effort and renewed attention to the public policy program as a whole.

Honors and Awards

We were particularly pleased and proud that the James N. Murphy Award -- given annually to an employee "whose spirited contributions to the Institute family have won a place in the hearts of students" -- was presented to Anne M. Grazewski, administrator for graduate student affairs. The award, based on a persuasive outpouring of nominating letters from graduate students in the Department, gave richly deserved recognition to the patience, warmth, and wise counsel that Mrs. Grazewski dispenses along with the more tangible products of her office.

The Department was gratified as well by the honorary degrees awarded two of our colleagues during commencement season this spring. Professor Walter Dean Burnham was awarded an honorary Doctor of Letters by Rutgers University. Referring to his writings on American politics, the citation described Professor Burnham as a "trenchant critic of the power of unbridled elites in a pluralist society." A Doctor of Laws was conferred upon Professor Lucian W. Pye by Carleton College. The citation referred to his stature as "one of the nation's most distinguished students of Chinese politics and the whole process of political development," making particular mention of his use of psychological and anthropological approaches to broaden our conception of politics.

Professor Michael Lipsky received two awards for his recent book *Street-Level Bureaucracy: Dilemmas of the Individual in Public Services*. He was given the American Political Science Association's (APSA) Kammerer Award for the best book on national policy published in 1980, and the Mills Award of the Society for the Study of Social Problems for the book that best exemplifies social science scholarship in the tradition of sociologist C. Wright Mills.

Highlights of Faculty Research and Professional Activities

Professor Hayward R. Alker was chairman of the Department's Graduate Program Committee and of the Computer Committee during the fall term. In the spring he was on leave, pursuing his research in international relations and political theory and participating in several international conferences.

Professor Alan A. Altshuler was Head of the Department through the fall term, serving simultaneously as co-director of the research program on the Future of the Automobile. He also 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. During the spring he concentrated on research and helped organize a conference in Japan, where he presented a paper on "Multinational Investment and Production in Automobiles."

Professor Suzanne Berger was editor and coauthor of two books this year: *Religion and Politics in Western Europe* and *Organizing Interests in Western Europe: Pluralism, Corporatism and the Transformation of Politics*. She continued to perform the sensitive task of chairing the Department's financial aid committee and was a member of the MIT Press editorial board. On the curricular front, she took the lead in developing a new graduate field in Political Economy.

Professor Donald L.M. Blackmer became Head of the Department in January, having spent the fall term on research leave in Europe exploring developments in left-wing parties. Since 1973 he had been the Associate Dean of the School of Humanities and Social Science, serving most recently as director of the Program in Science, Technology, and Society.

Professor Lincoln P. Bloomfield wrote several articles and published a new book, *The Foreign Policy Process: A Modern Primer*. He served on the boards of directors of the World Affairs Council, the World Peace Foundation, and the United Nations Association of the USA. He also chaired the Department's Undergraduate Program Committee.

Professor Burnham contributed chapters on electoral politics and other topics to four books published during the year and completed work on his own forthcoming book *The Current Crisis in American Politics*.

Professor Nazli Choucri continued her intensive association with the Technology Adaptation Program, serving as associate director and chairing the Policy Committee. Her many service activities included a term as council member of the APSA and editorial board member of three journals. She also published a new book, *Energy and Development in Latin America: Perspectives for Policy*, and edited and contributed to two others.

Assistant Professor Joshua Cohen, whose primary appointment is with the Department of Linguistics and Philosophy, served on several Department committees and taught subjects in political theory and political economy. The high quality of his teaching was recognized by the Department's graduate students, who voted him best teacher of the year. He continued work on a book and published a review article on Karl Marx's theory of history.

Senior Lecturer Edwin Diamond published a new study of television and American society titled *Sign Off: The Last Days of Television*. He also began work as editor of a four-nation comparative study of television systems.

Associate Professor Lloyd S. Etheredge was on leave in the spring term teaching at the School of Organization and Management, Yale University. He revised the manuscript of his book "Will Governments Ever Learn? - The Hope for Intelligence in Public Life."

Assistant Professor Thomas Ferguson was coeditor and coauthor of *The Hidden Election: The Politics and Economics of the 1980 Campaign*, a book which aroused considerable interest in the press and served as the focus of a panel at the APSA annual meeting. He gave a number of lectures and continued as a regular contributor to *The Nation*.

Assistant Professor John R. Freeman, who came to the Department in the fall from the University of Missouri, gave several conference papers and published two articles in his fields of political economy and empirical theory. He received a National Science Foundation grant to expand his work on governmental intervention in industrializing countries.

Associate Professor Ted R.I. Greenwood has nearly completed revisions of a book manuscript on "Knowledge and Discretion in the regulation of Hazardous Materials." His interest in risk and regulation also was expressed by participation in faculty seminars and teaching, and by his membership on the National Academy of Sciences Committee on the Institutional Means for Assessment of Risks to Public Health.

Professor William E. Griffith published a book, *The Superpowers and Regional Tensions: The US, the USSR, and Europe*, wrote articles on aspects of Soviet and American foreign policy, and participated in numerous international conferences.

Assistant Professor Emma Jackson spent the year at the Joint Center for Urban Studies gathering and analyzing data for a project on City Fiscal Crises and participating in a related study of the impact of Proposition 2 1/2 on Massachusetts cities and towns. She also continued to serve as executive secretary of the National Conference of Black Political Scientists and as secretary to the Executive Committee of the Women's Caucus of the APSA.

Professor Willard R. Johnson continued his research on development problems in Africa and on US policy toward Southern Africa. He published an article in *Daedalus* on African economies and the oil crises, and served on the board of directors of TransAfrica and of the African Heritage Studies Association.

Professor William W. Kaufmann participated in the Brookings Institution project on energy and national security, publishing papers on "The Defense Budget" and "Future Defense Postures." He was a member of the Institute Committee on Academic Performance and contributed to Departmental life by serving as registration officer for undergraduates and graduate students.

Professor Lipsky continued to be actively involved in urban affairs through research, training, and public service. As mentioned earlier, his recent book, *Street Level Bureaucracy*, received two important awards. He continued to teach in the Legal Services Institute, a training program concerned with providing legal and political analytic services to the poor, and contributed to other social and professional organizations. Within the Department he co-directed the Independent Activities Period program, and played a major role in the development of our new master's program.

Senior Lecturer Louis Menand III continued to divide his time between the Department, teaching American politics and serving as anchorman on the Undergraduate Program Committee, and his multiple responsibilities as special assistant to the Provost. His outside activities included being a trustee of Bradford College, a member of the Academic Freedom Committee of the American Civil Liberties Union, and an advisory board member of the Massachusetts Civil Liberties Union.

Assistant Professor Stephen M. Meyer completed two studies, one on elite attitudes toward nuclear decision making in India, the other (soon to be published by the Institute for Strategic Studies in London) on "Soviet Theater Nuclear Forces." He received a Defense Department contract for a two-year study of Soviet defense technology. His expertise in research methods was reflected in both a new course, "Interpreting Quantitative Research," and in his appointment as review editor for methodology of the *Journal of Public Policy and Management*.

Assistant Professor W. Russell Neuman edited and contributed to a book on *The Social Impact of Television* and completed an article for the *Public Opinion Quarterly* on "Television and American Culture." Through the Research Program on Communications Policy he is carrying out a new research project on the future of the mass audience.

Professor Ithiel de Sola Pool contributed to a number of volumes concerned with mass communications in the United States and other societies. He sent to press a book called *Forecasting the Telephone: A Retrospective Technology Assessment*. He also continued to devote prodigious intellectual and entrepreneurial energy to the development of the Research Program on Communications Policy.

Professor Pye published two books, a major study on *The Dynamics of Chinese Politics* and a monograph on *Redefining American Policy in Asia*. He was elected president of the New England Committee of the Association of Asian Studies, served as chairman *pro tem* of the National Committee on US-China Relations, and was director of the Council on Foreign Relations, the Asia Foundation, and the World Affairs Council of Boston.

Professor George W. Rathjens was active in arms control and disarmament issues in a variety of contexts, lecturing widely, serving on committees for the American Association for the Advancement of Science and the American Academy of Arts and Sciences, and contributing chapters to three books. He continued to chair the Department's graduate admissions committee and to cochair the Arms Control Program in the Center for International Studies.

Professor Robert I. Rotberg edited two books, one on *Imperialism, Colonialism, and Hunger*, the other on *The Political and Economic Development of Post-Independence Namibia*. He continued as coeditor of the *Journal of Interdisciplinary History* and was elected to the Council of the American Historical Association. He wrote several articles and lectured widely on politics in Southern Africa.

Assistant Professor Richard J. Samuels completed revisions of his book, *The Politics of Regional Policy in Japan*, which will be published by the Princeton University Press. His expertise on Japan was reflected also in articles on Japanese energy policy, and in his responsibilities as faculty consultant to the Industrial Liaison Program and as director of the MIT-Japan Science and Technology Program.

Professor Harvey M. Sapolsky is currently Associate Chairman of the Faculty, with the heavy load of committee assignments that accompany that responsibility. He found time as well to lecture and write articles on health policy issues and to complete work on *The American Blood Supply*, a book coauthored with Professors Alvin Drake and Stan Finkelstein.

Professor Eugene B. Skolnikoff continued to serve as director of the Center for International Studies and as chairman of the board of the German Marshall Fund. He wrote papers and gave talks on technology transfer and other issues concerning scientific and technical linkages between the United States and other countries. He was a member of the International Activities Panel of the National Academy of Sciences and chairman of the Academy's Chinese Science Policy Committee.

Assistant Professor Brian H. Smith published *The Church and Politics in Chile: Challenges to Modern Catholicism* and presented several papers on religion and politics in Latin America. He was appointed chairman of the Task Force on Academic Freedom and Human Rights of the Latin American Studies Association.

Professor Peter H. Smith was fully engaged as Head of the Department of Humanities and Associate Dean of the School of Humanities and Social Sciences. He also served as president of the Latin American Studies Association and completed papers on US policy in Mexico and on "The Return of Peron."

Associate Professor Deborah A. Stone published two articles, "Drawing Lessons from Comparative Health Research" and "Definition and Determination of Disability in Public Programs." She was a member of the executive committee and book review editor of the *Journal of Health Politics, Policy, and Law*. She directed the Department's undergraduate public policy program and served as principal liaison with the Technology and Policy Program in the School of Engineering.

Associate Professor Martha W. Weinberg was on leave for the year as visiting scholar at the Sloan School of Management. She served as a member of the board of trustees of the Massachusetts Cultural Alliance.

Professor Weiner pursued his research on international migration and development, publishing an article "Indians in the Persian Gulf" and a book, with Mary Katzenstein, *India's Preferential Policies: Migrants, the Middle Classes and Ethnic Equality*. He chaired a Salzburg Seminar on international worker migration, was keynote speaker at a Ford Foundation workshop in Sri Lanka, and continued as chairman of the Committee on South Asia of the Social Science Research Council. He took charge of the Department's Graduate Program Committee in the second term, concentrating on the development of a master's program in Political Science and Public Policy.

DONALD L.M. BLACKMER

Department of Psychology

In accord with the demands of the times, this Department is striving to maintain its integrity while developing new endeavors which have promise for the future. The following presents some of the details.

TEACHING AND TRAINING

Graduate Program

Perhaps the most striking event of the year has been the renewal of our training grant from the National Institute of Health (NIH). In the face of broad cutbacks in Federal training and research support, this renewal comes as an encouraging affirmation of the quality of the former fellows of the program, its current content, and its future prospects. Feedback from the reviewing committee was explicit in recognizing the uniqueness of the broad spectrum of disciplines and their coherence entailed in our program.

Given this approval, we have admitted a new class consisting of eight students selected from a pool of 73 applicants.

During the year we awarded five doctoral degrees bringing the total awarded from this Department in the course of 17 years to 82. According to a recent accounting of the graduates of the Department, all but three or four (of whom one is deceased) are either gainfully employed in the area of their training or in related fields. Although the sample is small, we have some sense that the employment pattern is changing. From the conventional area of employment in academia, where 66 percent hold appointments, our graduates increasingly appear to be entering industrially and medically related areas of research and development. This changing pattern of course reflects the decreasing opportunities in academia but it also reflects more positive developments. On the one hand, there is increasing recognition that psychologists trained in techniques for analyzing and studying human information processing are valued for work at the interface between humans and machines. On the other hand, the importance of neurobiological research in medicine is increasingly recognized and its practitioners appreciated. We, of course, welcome the positive trend and are taking actions to better prepare our students for anticipated opportunities. Accordingly, we have strongly supported the appointments of several neurobiologists which the space and funding of the new Whitaker College make feasible. These appointees will, we hope, work closely with our own faculty in this area to broaden our training program further.

In the area of cognitive psychology (human information processing) we have gained increased support with the advent of a large Sloan Grant for the advancement of cognitive science. New faculty and research support will strengthen training in this area. In the area of computational approaches to vision and the nervous system, collaboration with the Artificial Intelligence Laboratory has greatly enriched our staff and their support for training in this promising area.

Undergraduate Program

This year the Department made an unprecedented departure from previous policy by initiating and receiving approval for a program leading to an undergraduate degree in Cognitive Science. Although we have had undergraduates who spent much of their time working in this Department, no degree has been awarded solely from the Department. The new program will entail courses not only within the Department but also many selected courses from the Departments of Linguistics and Philosophy and Electrical Engineering and Computer Science. The combination of disciplines represents an approach to the psychology of human intellect which utilizes intellectual strengths unique to this Institute. We anticipate a small but continued enrollment in the coming years.

Colloquia

As in previous years we have attracted a large number (62) of visiting lecturers, including many from European laboratories. The presentations made by these visitors serve the community as well as the Department and are essential to our program. They provide updates on new developments in the field and disseminate information about our program.

RESEARCH

Despite current stringencies in Federal support of research, our faculty have managed to maintain the Department's level of external funding for research. But the search must go on for new sources of funding if we are to maintain our freedom to pursue research in accord with the needs determined by the state of the science as opposed to the goals determined by demands extrinsic to the science. In making this distinction, we do not deny that research may (indeed should) at times be relevant to practical goals, but rather reaffirm that research exclusively devoted to such goals soon loses its potential for relevance.

FACULTY

We are pleased to announce the promotion of Dr. Mary Potter to full professor. After a thorough search for a cognitive psychologist at the junior level, Dr. Steven Pinker, currently of Stanford

University and who earned his doctorate at Harvard, was invited to join our faculty. He has accepted and his appointment begins this year. This will strengthen our program in Cognitive Science.

Our faculty continues its highly productive way of life, publishing over 100 items, receiving invitations to join consulting and evaluating committees and election to head professional groups, delivering prestigious lectures, and receiving honors. Among the latter we cannot forbear to mention the honorary doctoral degrees awarded to Dr. Walle Nauta by the University of Madrid and to Dr. Norman Geschwind by the Claude Bernard University of Lyon.

PROSPECTIVE

The Department has long encouraged innovative collaborations with other Institute groups. Witness its participation in numerous on-campus developments, including the Division for Study and Research in Education, the Laboratory of Neuroendocrine Regulation, the Neurosciences Research Program, the Division of Health Sciences and Technology, the Artificial Intelligence Laboratory, and the Center for Cognitive Science, to mention only a few such endeavors. For the most part these participations have been mutually supportive and beneficial. However, they can exert pressure upon the Department and may be divisive insofar as they absorb faculty energies and funds central to the thrust of the activities and goals of the Department. In this vein, close collaborations with the Center for Cognitive Science and with the Artificial Intelligence Laboratory have been very beneficial.

The impending collaboration with the new and old faculty ensconced in the Whitaker Building, under the rubric of a section of Neuroscience, poses the question in rather acute form. For the first time in our history we shall have a significant geographical separation of that part of our faculty housed in Whitaker from the rest. The administration shares the Department's belief that the brain sciences in general, and the area of neurobiology in particular, are growth areas in that they are ripe for important new discoveries and increased support. But in an era of limited resources, even unlimited prospects are constrained by hard financial bounds. Allocation of resources becomes an acute question here, and careful leadership will be critical for maintaining the positive thrust of this Department while encouraging the new salient. One development to be fervently encouraged is the proposal that a new building adjacent to Whitaker be constructed so as to reunify the Department and further encourage the broad approach to the brain sciences that has been our hallmark.

We also look forward to the development of a number of burgeoning research endeavors including those in cognitive science, computational approaches to vision, movement, and the nervous system, and new approaches to neurobiological issues in medicine. The new undergraduate degree program offers a challenge to some of our faculty and its progress will be watched with interest. Our Visiting Committee has suggested that the Department needs a plan for its future in order to focus its needs and role within the Institute. We agree, but recognize that the dynamics of the situation are currently such as to make planning difficult.

RICHARD M. HELD

Program in Science, Technology, and Society

A major milestone in the continuing consolidation of the new Program and its naturalization into the MIT environment was passed in December, when the Program in Science, Technology, and Society (STS) moved into its new quarters in Building E51, a handsomely renovated building which the Program shares with the Sloan School. The new location offers the considerable advantages arising from close proximity of faculty members, fellows and other visitors, and graduate students, and the sharing of common-room, reading-room, and eating facilities. The outside support (Fleischmann Foundation) and the contribution of the Institute in making this possible are warmly appreciated.

The opening of the new headquarters was marked by a two-day symposium, made possible by support from the Barker Foundation. The topics of the three sessions reflected major themes of the Program: Science, Technology, and Everday Life; the History and Culture of Science and Technology; and Science, Technology, and the Wider Culture. Participants were divided among Program faculty, other MIT faculty, and distinguished outsiders from as far afield as California and England. The symposium helped present the purposes and interests of the STS Program to the rest of the Institute; it was well received, and the papers are being prepared for publication.

The new facilities improved an ongoing activity, the colloquium series, and made possible a step toward institutionalizing the STS connection with faculty in all of the Institute's Schools. The regular availability of an appropriately sized lecture room in E51 improved the physical circumstances and attendance at the colloquia. A dozen meetings were held, with the majority of speakers drawn from outside the Institute.

Forty faculty members (32 from MIT, with representation from all five Schools) and eight from Harvard, Brandeis, and Boston universities were invited to become faculty associates of the Program. A lunch for all Program members, faculty associates, research fellows, and graduate students was held every Friday during term time in the E51 dining area. Alternate Fridays featured a speaker -- some members of the group, some outside; the other days, simply informal conversation. Average attendance was in the thirties, indicating that one-half of those in the group came. Associates also served as members of promotion committees for STS junior faculty and were drawn on in other capacities for counsel and assistance to the Program.

The rest of this report discusses the major efforts of the Program on undergraduate curriculum development; personnel matters, including appointments, promotions, and honors; the fellowship programs and graduate students involved in the Program; the launching of a new venture; and some continuing needs.

Curriculum Development

The major collective effort of the Program was directed toward undergraduate curriculum development. One new program was initiated, two others are in process.

A new double-degree program will be offered starting next fall. STS and the Department of Humanities will offer a double degree with selected engineering and science departments for undergraduates who wish to integrate the professional study of engineering and science with the rigorous treatment of its relations to social and historical forces. The target for double-degree programs is always small, but those who take them include many of the best students at the Institute. This program has been approved by the Institute's Committee on Curricula and the faculty, and will appear in next year's catalogue listing. So far six of the eight departments in the School of Engineering have indicated their willingness to call the program to the attention of their degree candidates.

The second effort, which is still in its early stages, is the development of two kinds of STS subjects specifically aimed at attracting science and engineering students. One would be a course in the history and philosophy of science, directed primarily to freshmen and closely correlated with the material in 8.01 and 8.02, and 18.01 and 18.02. The course would discuss selected topics in the history of physics and mathematics -- which cannot be readily incorporated in the mathematics and physics subjects themselves -- in order to give the students some understanding of the historical development of science and exposure to philosophical ideas of what constitutes scientific knowledge and how it is validated. STS is cooperating in this effort with those faculty in the Departments of Mathematics and Physics responsible for the introductory courses.

The other group of courses would be aimed at juniors and seniors in engineering and science and would deal with some of the social problems implicit in the practice of engineering and science. These courses would be pitched at a level that draws on the technical knowledge of upperclassmen, and we would aim at teaching them jointly with the appropriate faculty members in engineering and science. Some of the possible course topics under examination are: "Dangerous Materials: Realities, Attitudes, Policies, Laws"; "Who Needs It? or Design as a Social Problem"; "Social Problems in Information and Communication Technology: Secrecy, Privacy, Access, Openness, Information Overload, Big Brother"; and "Problems in Biotechnology and Medicine."

Faculty

The year saw one new appointment at the junior level -- Sharon Traweek, jointly with the Anthropology/Archaeology Section in the Department of Humanities, as an assistant professor. Dr. Traweek comes from the University of California at Santa Cruz; her research is a comparative anthropological study of Japanese and American high-energy particle-physics groups. Kenneth R. Manning, an historian of science working on both the history of mathematics and blacks in science in America, was promoted to associate professor with tenure. Two were promoted from assistant to associate professor: David Noble, an historian of American technology, and Charles Sabel, a political scientist studying the effects of technical change in the work place on the social and political organization of workers.

Professors Loren Graham, Merritt Roe Smith, and Sherry Turkle all received important outside recognition for their scholarly achievements. Professor Graham, historian of Russian science on leave this year, was a fellow at the Woodrow Wilson Center and the Kenan Institute of Soviet Studies in Washington for the fall term, and spent the spring term in the Soviet Union as a National Academy of Science and IREX exchange fellow. Professor Graham's book, *Between Science and Values* published by Columbia University Press, has drawn much favorable comment. Professor Smith has been awarded a Guggenheim Fellowship for the next academic year, a Regents Fellowship of the Smithsonian, a Fulbright Scholarship, and a Fellowship of the American Antiquarian Society. He had to turn the latter down as he could not hold it simultaneously with the others. Professor Smith's pioneering book on the Harpers Ferry arsenal continues to stimulate discussion and command wide attention among historians of technology, as evidenced by extensive commentary in recent issues of the *Journal of American History* on the book's contribution to the shaping of the history of technology as a separate discipline. Professor Turkle, on leave this year, held a Guggenheim Fellowship and an award from the Rockefeller Foundation. Professors Manning, Noble, Sabel, and Traweek have books in press.

Fellowship Programs, Visiting Scholars, and Graduate Students

The Exxon Fellowship Program permitted us to invite five fellows: Harley Balzer, fellow, Harvard University Russian Research Center, whose major research interests center on Russian and Soviet social history, with particular attention to the technical intelligentsia and professionalization; John Broomfield, professor of History, University of Michigan, who examined the worldwide influenza pandemic of 1918; Martin Krieger, visiting assistant professor, Department of Urban Studies and Planning at MIT, whose original training was in physics, is exploring how the toolbox of physics is similar to and different from that of the social sciences and the practical decision maker; John Weiss, assistant professor of History at Cornell, whose work involved the completion of a three-part study of the French engineering profession; and Rosalind Williams, who is writing on topics involving the relationship between technology and general culture in 19th- and 20th-century Europe. Dr. Williams continued on a part-time basis the Exxon fellowship she held on a part-time basis last academic year.

In addition, there were three visiting scholars who worked on the same basis without compensation: Haroun Jamous, a student of the sociology of innovation from the Centre de Sociologie de L'Innovation, Ecole Nationale Superieure des Mines in Paris for the second term; Evelyn Keller, a fellow last year and visiting professor at Northeastern University during the current academic year who continued her work on women in science; and David Nye, assistant professor of American Studies at Union College, whose independent research under a grant from the National Endowment for the Humanities concerns the cultural dimensions of technology as reflected in the General Electric Photographic Archives, where he spent the whole academic year.

They all had a fruitful experience. Two of them completed books which appeared during the year. The University of California Press published Rosalind Williams's *Dream Worlds of the Consumer: Critiques of Consumer Society in Late Nineteenth Century France,* and the MIT Press published John Weiss' *The Making of Technological Man: Industrial Science and Social Stratification in French Engineering Education.* Evelyn Keller's scientific biography on Barbara McClintock is in press. The flavor of the fellows' experience is best given by a passage from the final report of John Broomfield:

> I had an extremely productive and intellectually valuable year as a Fellow with the Program, and I wish to thank you and your colleagues for making this possible. The strengths of the STS

> faculty -- in the history and philosophy of science, science policy, and the social consequences of technological development -- were exactly in the area I needed to extend my own individualistic, and previously rather undirected, explorations. I found the balance just right between, on the one hand, ample opportunities to interact individually and in seminars with other Program members, and undisturbed time to think and write. The permanent faculty in the Program were friendly and encouraging with the work we Fellows were engaged in, and always ready with suggestions of outsiders whom we might find useful, in other MIT units and in other Cambridge-Boston institutions. In this respect, I made valuable contacts in the Department of Political Science (particularly the Health Policy group), in the History and Anthropology sections of the Department of Humanities, with my compatriot the Dean of Humanities, and at Harvard with the Department of the History of Science, itself so closely involved with STS.
>
> John Weiss is to be congratulated in moving, early in the fall, to initiate the weekly Fellows Seminars, which proved invaluable as a forum of mutual discussion and an arena in which we could have discourse with faculty inside and outside the Program. Speaking of the Fellows as a group, and including of course David Nye and Haroun Jamous, I would say that they were exceptionally collegial and generous with their time in assisting each other with ideas, references, and criticisms. I think this in itself is testimony to the quality of the Program's selection procedures.

A new fellowship program supported by the Mellon Foundation was initiated. Unlike the Exxon Fellowships, which support the research of the recipients in STS fields, the Mellon Fellowships are aimed at helping postdoctoral scientists and engineers who wish to venture for the first time into historical and social studies of science and technology. The first four fellows were selected from 40 applicants of surprisingly high quality, given the novelty of the scholarships and the short time we had to advertise them.

The successful candidates who will spend the next academic year with the Program are: Joseph Alper, associate professor of Chemistry at the University of Massachusetts at Boston, who proposes to study the reciprocal relationship between the influence of values on scientific theories and the application of scientific theories to political and social issues; Stephanie Bird, staff scientist, Neurosciences Research Program at MIT, who will examine some of the ethical issues at the interface of biological science and society from the point of view of her discipline; Marcel Coderch, having just completed a Ph.D. in Electrical Engineering at MIT, who plans to explore the international dimension of technology development and its effect on the international division of labor; and Muriel Gillick, M.D., resident in Geriatric Medicine at University Hospital, whose interests lie in the history of the decline of long-term treatment hospitals and primary-care medicine.

There were two other visitors in academic year 1981-82. The first is Julian Gresser, professor of Law at the University of Hawaii, who will be with us next year as well, dividing his time between the Program and the Harvard Law School; he was a visiting professor here and a lecturer on Law there. Professor Gresser is one of the leading American students of Japanese law. He is now examining the legal and administrative basis for Japanese promotion of high-tech industry in a book that he expects to finish during his stay. He taught a seminar on these topics at the Law School in the spring term and conducted one for faculty and graduate students here in the fall term. The second is Harley Shaiken who came as a fellow in 1980-81, and continues as a research associate jointly with the Program and the Center for Manufacturing Productivity. He is working on the effects of technical change on jobs, with particular reference to the automobile industry.

The program was host to 10 graduate students almost all of whom were registered in the Department of Political Science, but had elected to work in the STS Program under Program faculty. This year among the six top-ranked, newly admitted graduate students in Political Science (as ranked by the Department's fellowship committee), four were coming to work in the STS Program. In addition, one student in Economics and one in Urban Studies worked in the Program. All were given space by the Program and participated in its seminars, colloquia, lunches, and other

organized activities. Both they and we have found the interaction valuable. The main teaching purpose still focuses on undergraduates, but the STS faculty, like every good research-oriented group, finds special stimulus in the challenge of graduate students and the arrangements with the Departments of Political Science, Economics, and Urban Studies and Planning have so far provided a workable method of meeting that desire.

The New Venture

The launching of a new educational effort somewhat different in kind from either its undergraduate program or conventional graduate programs was perhaps the most venturesome undertaking of the Program in the past academic year. We aim at creating visiting fellowships in the Public Understanding of Science and Technology -- to be called Vannevar Bush Fellowships -- open to journalists writing for magazines and newspapers; writers and directors of science and technology programs for radio and television; and for journalists, scientists, and engineers who write books for the general public. The fellowships would also be open to expositors of science and technology working in either government and industry rather than as journalists. Those chosen as fellows usually would be expected to have three to five years' experience in exposition of science and engineering to the public. They would spend an academic year at MIT in a seminar especially designed for them by our faculty members, write a substantial paper for the seminar, and take appropriate courses and seminars throughout the Institute by individual arrangement with instructors. Victor McElheny, a former Nieman Fellow whose experience as a science journalist includes work for the *Boston Globe*, the *New York Times*, and *Science*, has joined the Program as a research associate to organize this effort and help find support for it. Our initial presentation to two foundations has met with an encouraging response. Next year will be spent in planning the program, securing its financial support, and making it known to the journalistic and writing worlds from which we expect to draw the candidates who will come to MIT as Vannevar Bush Fellows. We expect to have the first group of fellows come in academic year 1983-84.

Continuing Needs

Like every other department at MIT, the STS Program needs money. Our foundation grants, which have several more years to run, have been a major source of support. We are already energetically seeking to replace and supplement these.

In terms of faculty, the Program now appears to be reasonably well balanced with one striking exception. There is no senior member and, indeed, no regular member at all with graduate training in the biological sciences. At present, Robert S. Morison, a distinguished physician several times emeritus who participates as a visiting member, is our only biological scientist. In view of both the intellectual vitality of the biological sciences and their potential as a source of novel technology and consequent novel social problems, we feel this is the major deficiency. We are now seeking to interest a biological scientist already on the MIT faculty in committing a substantial part of his time to the Program.

CARL KAYSEN

Sloan School of Management

The principal activities of the Sloan School of Management (SSM) continue to focus on research dealing with important management issues, and on the education of both management professionals and the educators of the next generation of management professionals and researchers.

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 master's and executive education programs, as well as our undergraduate program, are our principal opportunities for affecting the quality and practice of management, not only in this country but elsewhere, through the dissemination of ideas impinging on that practice. Our doctoral program aims essentially at the training of future educators of management professionals and trains these persons to engage in the serious research which must underlie any successful efforts at professional education. Our research activities have continued to seek 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 perspectives, but geared for the longer term and thrust. All of these activities continue to merit the high national and international reputation of the School's programs and research.

In my last report, I described some of the task forces we had established to help us look hard at our activities and possibilities. These have been quite successful in many ways. The extended conversations in and out of the School, held in conjunction with the preparation of the task force reports, have helped us build a great many new and renewed intellectual bridges. The reports and the discussions of these reports by the School's Council (29 faculty and administrative staff) at a three-day retreat held last April all endorsed the core mission which we have pursued from the School's earliest days.

Since the inception of the Sloan School, the faculty and staff have sought to have an impact on management practice through research and teaching; the task force recommendations and the Council's discussions put some new spin on this basic thrust as did the discussions of their subsequent review at a meeting of the entire Sloan School faculty in late April. A number of "next action steps" have been proposed, endorsed, and begun to be implemented. The recommendations centered on: a) the selective investments we needed to make in several of our ongoing teaching programs and in some exciting possibilities for more focused (rather than general) management education programs for alumni and other executives; b) a regrouping of a number of our discipline and application domains into broader area clusters to encourage and strengthen intellectual interaction; c) the creation of incentives for more cross-disciplinary and integrated teaching and research to permit us to deal more effectively with a number of critical managerial policy and strategy issues which are less easily dealt with through more partial analyses; and d) the substantial strengthening of our efforts in external relations, including alumni relations, media and information relations, and resource development activities.

We have already implemented the recommendation on academic area reorganization, and have grouped ourselves into three large areas -- management science, applied economics and finance, and behavioral and policy sciences.

We have decided, albeit reluctantly, to discontinue the offering of the 12-month accelerated master's program to permit us time and resources to continue to upgrade the design and accommodate the proposed increased size of our two-year master's program and to permit us as well to initiate extensive redesign and expansion of our senior executive program. In addition, we are undertaking the design of a number of shorter senior executive programs focused on specific management areas.

We also have continued to make good progress in expanding and improving our program for SSM alumni relations. As I noted in last year's report, one of the questions we tried to address over the last two years as part of our renewed effort at building on our legacy of excellence was the regeneration of links and communication amongst ourselves, with others at MIT, with our many corporate friends and sponsors, and with our alumni. The widespread distribution of the first issue of the School's annual report in 1981, which included a bit of history -- a snapshot of what we had wrought over time, where we are now, what challenges needed to be addressed and what opportunities seized -- was step two in telling our alumni and friends about the state of the School and in seeking their inputs. Summer 1981 also introduced a set of annual summer gatherings at which hundreds of our graduates came together in four different cities.

We already have associations of undergraduate and executive program alumni, and in the past year we have established a similar structure for master's and doctoral graduates as step three in revitalizing ties between those of us working here at Sloan and MIT and our alumni. *SLOAN*, the first issue of a semi-annual magazine targeted principally for graduates of the Sloan School, has thus taken us now to step four in getting us closer to our alumni.

In all of this, we have been encouraged and helped substantially by a dedicated group of master's students who took it upon themselves to study the area of communication with alumni of the School. More than 2,500 alumni were surveyed; a large number responded providing us with invaluable information on what would be useful services we might provide for them.

Finally, we have continued to make good progress in the expansion and refurbishing of our physical plant. The completion of construction at 70 Memorial Drive permitted us to begin to use, in January 1982, the wonderful new classroom and seminar room facilities. Demolition in the first two levels of 50 Memorial Drive began in March 1982 and, by March 1983, the School should have in place its new teaching program offices, student spaces, improved computer facilities, *Sloan Management Review* offices, and informal dining arrangements for use by students in all of our programs. Construction of a new facility at the Endicott House grounds began in May, with completion expected in December 1982. The new facility will permit us to expand the size of our senior executive program and to design several new executive programs which will be focused on specific management areas to supplement the general management focus provided by the senior executive program.

Our alumni and other individuals and organizations have continued to strive to provide increasing levels of gift giving to the School, but we still expect to make substantial progress in both our alumni- and corporate-related resource development activities.

We have also made substantial improvements to facilitate teaching and research as well as learning. We acquired in April 1982 a larger computer -- the PRIME 850, replacing the five-year-old PRIME 400 -- allowing us to reorganize the computation facility to link Economics, Political Science, the research centers in E40, and all parts of the Sloan School. In addition, we introduced in September 1981 decentralized communicating word processing for use by academic and administrative groups with good results.

Most significantly, the School has continued to seek and receive the help of the central MIT administration, of our alumni, and of our corporate and individual friends in planning future efforts to develop the School's needed resources. These include graduate fellowship support in our doctoral program and other forms of support 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 have had continued support from Senior Vice President William Dickson and his staff in developing our plans for the completion of the upgrading of facilities in the Sloan Building and in working with us on a myriad of support services. We also have received encouragement from a number of colleagues in other departments and Schools in our efforts to maximize the potential intellectual advantages of further links between the Sloan School and the rest of the Institute.

The year has been an encouraging and fruitful one, and the coordinated School and MIT campaigns on behalf of the School cannot help but result in the sharpening of the School's national and international image.

TEACHING PROGRAMS

Undergraduate Program

The total enrollment in Course XV for the 1981-82 academic year was 85. Thirty-one of these students received the Bachelor of Science in Management. Of these, 11 were in Management Science, four in Behavioral Science, one in Dynamics of Management Systems, and 15 in the following approved special programs: Management Information Systems (three); Applied Economics (two); Economics and Finance (two); International Management (two); and one each in Construction Management, General Management, Industrial Management, Management and Law, Management of Technology, and Marketing.

Five of our graduates also received bachelor's degrees from other departments, and one received the S.B. and S.M. in Management concurrently. There are eight students scheduled to receive two degrees in 1983.

Enrollment in the four programs for each undergraduate year are summarized as follows:

	Program 1 Special Programs	Program 2 Behavioral Science	Program 3 Management Science	Program 4 Dynamics of Management Systems	Total
4th year	18	4	18	2	42
3rd year	9	2	13	1	25
2nd year	6	0	11	1	18
Total	33	6	42	4	85

Our undergraduate core subjects again attracted a significant number of students from other degree programs at MIT. During the past year, there were 310 subject enrollments by non-Course XV students in our five undergraduate subjects. This is equivalent to 39 additional full-time students (about 45 percent of our undergraduate student body). In addition, 30 students, 12 of whom were from other departments, participated in the Undergraduate Management Game during the January Independent Activities Period (IAP). Three of these 12 students are planning to receive a second S.B. in Course XV.

For the first time in several years, the Sloan School participated in the Undergraduate Seminar Program. The seminars are six-unit pass/fail subjects, generally concerning topics not likely to be found in regular departmental curricula. This fall, the Sloan School offered a subject in Management of Student Organizations, with an enrollment of 20. The seminar was taught by Stephen Immerman of the Office of the Dean for Student Affairs, with faculty supervision by Professor Jeffrey A. Meldman.

Joyce L. Pollock, a senior in Management Science, was awarded this year's Sloan School Senior Prize for high scholastic standing, leadership, and professional promise. Ms. Pollock also received this year's Laya W. Wiesner Award, presented by MIT to the undergraduate woman who has most enhanced MIT community life. Three other Institute awards went to Sloan School undergraduates this year: Winthrop B. Cody and Edward L. Sanders each received the William L. Stewart Award for outstanding contributions to extracurricular life at MIT, and Rhonda Peck received the Karl Taylor Compton Prize for outstanding contributions in promoting high standards of achievement and good citizenship within the MIT community. These four MIT awards represent about 15 percent of the Institute awards received by departmentally affiliated undergraduate students this year.

The undergraduate program was chaired by Professor Meldman, with Esther Merrill serving as program coordinator. Professors Thomas J. Allen, 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 James B. Orlin served as the Sloan School's coordinator for UROP. Professor Meldman coordinated the Sloan School's IAP offerings in January.

Master's Programs

The master's programs continue to attract a large and well-qualified applicant pool. This past year, 1,650 individuals competed for 195 places -- 45 students entering the 12-month accelerated master's program, and 150 students entering the two-year master's program. The Master's Programs Committee successfully clarified the qualifications of candidates we are seeking and refined the admissions procedure. The revamped admissions process -- supported by our new data management system -- worked much more smoothly than the previous system, and we are confident it has yielded an impressive entering class. The Committee also tackled some difficult questions about how we schedule our master's-level subjects, and recommended a revised procedure which should reduce the number of conflicts faced by our students, while retaining a substantial amount of scheduling flexibility for faculty.

Exposure to leaders of the management world increased greatly this past year through the "Distinguished Speakers Series," an event managed by a student board of master's and doctoral students. The presidents of Exxon and Ford, the chairman of Shearson/American Express, the vice chairman of Intel Corporation, and the vice president for marketing of American Telephone and Telegraph (AT&T) visited the School and addressed the students and faculty on important issues facing their companies and industries. The "Human Resources Group," begun in 1980-81, continued to grow and flourish, inviting several professionals involved in human resource management to the School for informal presentations. A "finance club" has also begun to take shape and should be ready by the fall of 1982 to sponsor presentations by leading members of the financial services industry. These increased opportunities for our students to interact with practicing managers contribute significantly to our students' understanding of the complex management world.

The School honored several master's students for academic excellence and professional promise. First-year students Paul W. Jahn and Eileen R. Kleiman were named Proudfoot Fellows and received awards established at the School by the Alexander Proudfoot Company to honor the memory of its founder and to develop an awareness that productivity is a major concern for American industry. Douglas J. Honnold was named the first recipient of the Bendix Fellowship, which was established in 1982 to honor a first-year student. Panayotis E. Cavoulacos received the Henry Ford II Scholarship, an award established at the School by the Ford Motor Company fund and presented annually to a second-year student. Another second-year student, David M. Marieni, was the first recipient of the Henry B. duPont Scholarship, which was established by the Crestlea Foundation, with a gift from the late Henry B. duPont. James W. McCurdy received the Thomas M. Hill Prize, awarded annually to a second-year student who has demonstrated excellence in the field of accounting. This 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. We also presented the Brooks Prize for the best master's thesis in 1980-81 to Robert C. Salipante. Honorable mentions went to Mauricio Sancho Obregon and John P. Wolkonowicz. This prize was established by E. Pennell Brooks, first Dean of the School.

The following data highlight some of the major characteristics of the classes of 1982 and 1983 for both the Sloan master's program and the accelerated master's program.

	Sloan Master's Program		Accelerated Master's Program	
Characteristic	1982	1983	1982	1983
Sex: female/male	31/86	31/96	8/34	7/37
Age: median/range	24/20-36	24/20-37	28/24-42	28/24-38
Percent with full-time experience	73%	79%	100%	100%
From: countries/states	16/22	16/23	6/17	6/10
Mean undergraduate grade point average*	4.4	4.5	4.5	4.3
Median admission test score**	640	650	637	660

* On 5.0 scale (excluding most foreign students)

** National average is approximately 460.

As noted earlier, the accelerated master's program will be discontinued after this year, making this the last graduating class of this program.

The number of organizations recruiting on campus for master's programs graduates in 1981-82 dropped somewhat at Sloan, as it did at all other business schools in this recession year. We still had more organizations than job-seeking candidates, but the drop was still somewhat disquieting for a time until recruitment results were in. Although the number of organizations interviewing on campus for summer opportunities also declined a bit, the number of organizations that offered summer opportunities by telephone or correspondence rose by more than 50 percent. The net 1981-82 action suggested some observable exchange of summer internships for "real" jobs in companies' summer recruiting activities. These changes, experienced to some degree at all the top business schools in the country, were also directly attributable to the current recession. Some organizations reduced, or eliminated altogether, M.B.A. hiring this year. Others went instead to more "second-tier" business schools.

Although the Placement Office is an excellent source of career information, it was a frustration to some students that the Office was not also a source of jobs. Throughout the year, the Office took initiatives, many of them successful, with organizations and with alumni in an effort to increase its knowledge of available positions, but we believe that a significant upturn in recruitment visits will have to await an improved economy.

Nevertheless, there were many bright spots during the year and net placement results were, in the end, better than last year's, although choices may have been more constrained. In the fall, a record 46 organizations came to Sloan to make recruiting presentations to students. High-technology firms and their growing number of spin-offs recruited at Sloan with vigor. Investment banks sought out Sloan students with enthusiasm, and a record 10 percent of the class of 1982 joined Wall Street firms, up from 2 percent in 1981. Consulting experienced renewed popularity: 28 percent of the class accepted consulting positions, up from 18 percent in 1981, and closer to the 34 percent of 1980.

While the aggregate number of total offers was down, salaries were up. The mean starting salary was $37,000; in 1981 it was $34,200. By graduation, 85 percent of the class of 1982 had made postgraduate plans, the percentage nearly identical to that of 1981. Fifteen percent of the members of the two-year program accepted full-time positions with their first-year summer employers, and 21 percent of the members of the accelerated master's program chose to return to their former full-time employers. It is interesting to note that 25 percent of the graduates who took jobs did not accept the jobs which offered them the highest salaries, and more than half of the graduates included dual-career considerations in their job selection process.

The Master's Programs Committee was chaired by Professor Gabriel Bitran, who gave unstintingly of his time to the Committee and accomplished a great deal. Dr. Jeffrey A. Barks, director of master's programs, continued to provide imaginative and effective administrative leadership. Ms. Miriam Sherburne, director of master's admissions and counseling, completed more than 44 years of dedicated and professional service to the School, an association treasured by all of us at Sloan. Ms. Sherburne, along with Harriet Barnett and James Gabbert (who joined the staff of the master's programs this past year from the doctoral program), worked very hard in evaluating applications to our master's programs. In a particularly tight economy, Paula Cronin, director of placement, performed her career and placement duties admirably, while at the same time editing the first issue of *SLOAN*, our new alumni magazine.

Joint Program in the Management of Technology

Initial implementation occurred this year for the new MIT 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 received its first pilot class of six students in June 1981, awarded them degrees in June 1982, and welcomed the second pilot class soon thereafter.

Aimed at engineers and scientists with a minimum of five years of work experience, the first two classes actually have averaged 12 years of technical and managerial experience. The Joint Program is striving to 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 have developed and implemented 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. The new subjects also have attracted enthusiastic registration from regular graduate students throughout MIT.

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 its conception of Jane 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 (CGSP), the Committee on Educational Policy (CEP), and finally the MIT faculty as a whole, in an unprecedented unanimous vote of the Faculty Meeting.

Intending to provide better-trained managers of technical functions and organizations, the Joint Program will remain at this pilot size for the second academic year (1982-83), and then gradually begin to scale up to its eventual full program target of 40 to 50 participants per year. The rigorous curriculum has included an intensive core of analytic subjects taken during the summer with the Sloan School's accelerated master's program, in-depth studies of the management of technical people and programs, and a related thesis. Termination of the accelerated master's program in June 1983 will require that the Joint Program take responsibility for its summer subjects next year.

Program implementation could not have occurred without the strong and effective collaboration of the Deans' Offices in both the School of Engineering and the Sloan School of Management. 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 healthy 181 applications were received for fall 1981, sustaining the program's demonstrated growth in recent years. Admission was offered to 27 applicants, and 18 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 seven citizens from foreign countries.

The major fields of the entering class of 18 were distributed as follows: Applied Economics -- four, Finance -- six, Health Care Management -- one, Industrial Relations -- two, Management Information Systems -- one, Operations Research -- one, Operations Management -- one, Organization Studies -- one, and System Dynamics -- one.

A major shift that has continued 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 69 percent in 1981. 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 1981-82, 11 doctorates were granted in Management, reflecting the average size of incoming classes of 17-20 each fall term. Of those 11, six assumed academic positions at one or another of the following institutions: Harvard, University of Illinois, MIT, and Boston University. The remaining five pursued private research with A/S Computas (Norway), duPont, and Conoco.

The Ph.D. Committee, chaired by Professor Thomas Allen, faces two difficult and interrelated problems. First, just maintaining the long-established size of the program (ideally, 20 new students per year) has proven difficult in the face of stiff competition from other management schools which are able to make more attractive, longer-term, financial awards to prospective students. Second, since the incoming class of 20 students is distributed across 14 major fields, many areas lack a critical mass of doctoral students and are unable to offer a sufficient or

desired number of 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 continues to be made in expanding the program's resources.

Alfred P. Sloan Fellows Program

On June 1, 1982, 54 Alfred P. Sloan Fellows were awarded the Master of Science in Management. The Class of 1982 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 US, and is now in its 51st year.

Just prior to their graduation, the Sloan Fellows completed a three-week international management field trip to Asia. The Sloan Fellows visited the People's Republic of China, Hong Kong, and Japan. A highlight of the trip was a meeting with the vice premier of China in the Great Hall of the People.

A comparison of the Class of 1981-82 with previous classes follows:

	74-45	75-76	76-77	77-78	78-79	79-80	80-81	81-82
Industry								
United States	29	21	25	26	31	30	31	30*
International	5	11	11	14	10	11	13	15
Government								
United States	11	11	8	8	5	5	8	7
International	1	1	1	5	2	1	0	0
Other								
World Bank	0	0	1	0	0	0	0	0
Municipal Management	1	1	1	0	0	0	0	0
Medical Management	0	6	6	2	6	6	2	4*
Church Management	1	1	0	0	0	0	0	0
University Management:								
United States	3	2	1	0	0	2	1	1*
Foreign	0	0	0	0	0	1	1	0
	51	54	54	55	54	56	56	57

* Medical Management Sloan Fellows also counted in US Industry and University columns.

The demand for the program continues to be strong, and the quality of the nominations is extremely high. On June 16, 1982, the Class of 1982-83 arrived; there are 55 participants in the 1982 program. Countries represented in the program are: Austria, Belgium, Brazil, Canada, Japan, Malaysia, Mexico, Sri Lanka, and Venezuela.

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 Arnoldo C. Hax served as chairman of the faculty program committee.

Health Management Executive Development Program

The seventh year of operations was completed by the Health Management Executive Program as an integral part of the Alfred P. Sloan Fellows Program. There were four Sloan Fellows from the medical field: Edward E. Heller, Jr., executive vice president, Professional Services, Spectra Medical Systems, Whittaker Corporation, Sunnyvale, CA; Sheryl A. Jacobson, director of Dental Services, Chelsea Health Center, Massachusetts General Hospital, Chelsea, MA; Faith B. Rafkind, health care consultant, Washington, DC; and Elisabeth A. Zinser, Dean, College of Nursing, The University of North Dakota, Grand Forks, ND.

Oversight of the special aspects of this portion of the Sloan Fellows Program was shared by Professor Roberts and Mr. White.

Program for Senior Executives

Now in its 26th year, the MIT Program for Senior Executives enrolled 58 men and women in the two sessions held during 1981-82. The majority of the participants continue to be sponsored by US industrial organizations, with the remainder coming from public utilities, financial and business services, and the Federal government. Approximately 25 percent of the executives came from abroad, with representatives from the United Kingdom, Italy, Saudi Arabia, Hong Kong, Denmark, the Netherlands, India, Bangladesh, Trinidad, Switzerland, Australia, Canada, South Africa, and Japan.

During the year, Professor Michael S. Scott Morton was named chairman of the program's faculty committee, while Dr. Scott Duncan continued as program director.

Greater Boston Executive Program

The Greater Boston Executive Program (GBEP) marked its 25th year of operation. It ran from January 29 through May 7, 1982. There were 19 participants representing 11 corporations.

We had a new addition to the Administrative Committee from the First National Bank of Boston. The other representatives of the Administrative Committee are from W.R. Grace & Company, John Hancock Mutual Life Insurance Company, Alpha Industries, Inc., New England Telephone Company, Polaroid Corporation, Boston Edison Company, Massachusetts High Technology Council, Inc., and the Federal Reserve Bank of Boston.

Summer Programs

Members of the Sloan School were responsible for 14 of the Special Programs offered in the 1981 MIT Summer Session.

Professor Roberts again directed the two-week program Management of Research, Development, and Technology-Based Innovation and the one-week session on The Dynamics of Health Service Systems: Strategic Planning for Complex Health Organizations. He was assisted in these programs by other members of the School faculty, including Professors Allen, Richard Beckhard, Stan N. Finkelstein, Arnoldo C. Hax, Glen L. Urban, and Eric A. von Hippel; and Senior Lecturers Ralph Katz and 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.

Professor Stewart C. Myers of the Finance Group, assisted by Professor Gerald A. Pogue of Baruch College, The City University of New York, presented the two one-week programs on Modern Concepts in Financial Management and Models for Financial Management and Planning.

Professors John J. Donovan and Stuart E. Madnick offered two one-week courses in the management information technology field: Advanced Software Concepts - Operating Systems and Key Aspects of Information Systems Technologies: Database Systems, Telecommunications, and Performance Evaluation.

Members of the Accounting and Control Group offered three one-week programs. Professor H. David Sherman and Dr. Morris McInnes cochaired Planning and Control in Nonprofit Organizations; Dr. McInnes also worked with Professors Peter Brownell and Michael van Breda on the two consecutive one-week programs in Financial Planning and Control; the first week was devoted to Foundations and Methodologies and the second to Design of Systems.

In the operations management area, Professor Hax chaired the one-week program, Strategic Planning Systems. Professor Scott Morton of the School, and Walker Lewis, founder and president of Strategic Planning Associates, also participated. Professor Hax, together with Professors Bitran and Graves, worked with Harlan C. Meal, senior lecturer, in the presentation of a shorter three-day program on Hierarchical Production Planning Systems.

From the Operations Research Group, Professor Jeremy F. Shapiro, who also serves as co-director of the MIT Operations Research Center, was responsible for two programs. 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 Science, and Paul S. Bender, director of resource allocation Systems at International Paper Company, assisted Professor Shapiro in presentations for the second program, Resource Management: A New Approach to Corporate Planning.

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 two other summer seminars. The School's Center for Information Systems Research offered its sixth annual summer seminar, Current Issues in Information Systems: Managing in the Information Era at the Hyatt Regency Hotel in Cambridge.

The Marketing Center of the Sloan School conducted a three-day seminar at the Institute in July entitled Marketing Science: Strategy, Methods, and Models. Parallel sessions were held on industrial and consumer marketing. Professor John R. Hauser was director of the program. Other faculty presenting sessions were Professors Urban, John D.C. Little, Richard P. Bagozzi, Alvin J. Silk, Richard L. Schmalensee, Gary L. Lilien, Roy E. Welsch, and Lester C. Thurow.

Industrial Liaison Symposia

Many of the School's faculty also participated in three of the symposia conducted by the Industrial Liaison Program. In December, Professor Edgar H. Schein chaired a one-day program, Organizational Studies and Human Resource Management. Other participants in the program were Professors Beckhard, Allen, Lotte Bailyn, John E. Van Maanen; and Senior Lecturers Dr. Katz and Dr. Edwin C. Nevis.

Professor Hax was chairman of a two-day symposium on Productivity Management in March. Other faculty conducting sessions included Professors Thurow, Urban, Robert B. McKersie, Edward H. Bowman, Thomas A. Kochan, Richard D. Robinson, and Thomas A. Barocci, and Senior Lecturers Meal and Gordon F. Bloom from the Sloan School; Professors Nam Suh and James Utterback from the School of Engineering; and Robert Lund from the Center for Policy Alternatives. MIT alumni Howard S. Samuels, former Under Secretary of Commerce, and Arnold S. Judson, chairman of Gray-Judson, Inc., also participated.

Professor Zenon S. Zannetos was the chairman of Corporate Strategy: What is in the Future", a one-day symposium held in April. Other faculty participating were Professors Urban, Scott Morton, Robinson, Bowman, Roberts, Hax, Gordon B.M. Walker, Donald R. Lessard, Mel Horwitch, and Senior Lecturer Morris McInnes.

Professor Peter G.W. Keen conducted a session on Organizational Strategies for Office Technology during the one-day symposium held in May, Developing and Implementing a Corporate Office Automation Program, chaired by Dr. Marvin A. Sirbu, Jr., of the Center for Policy Alternatives.

These special summer and liaison programs continue to serve an important dual role. They offer specific post-experience training to professional managers and consultants to managers, but 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 -- once again about $2.4 million during fiscal year 1982 -- 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, anthropology, economics, and so on are the disciplinary bases upon which much of the research here builds.

Organization Studies. For the past decade the faculty of the Organization Studies Group has attempted to understand the dynamics of behavior in organizations, especially the relationship between the individual and the organization. From the point of view of the organization, we want to know what leads to productivity, innovation, and overall long-range effectiveness. From the point of view of the individual, we want to know what provides total life satisfaction and sense of success throughout the course of career and life. From the point of view of the interaction between the individual and the organization, we have looked at the dynamics of communication, at the innovation process, at the socialization and career development of managerial, technical, and professional personnel, and at the process of change and organization development.

To understand these dynamics we have had several distinct foci, each of which provides a different but relevant perspective on the basic question:

1) The Study of Organizational Culture, Structure, and Style. Several projects have contributed to this area over the years: Professors Beckhard and Schein have organized a group of family-owned companies to study the dynamics of organizational evolution, how business and family issues come to be segregated and worked on, and how culture is formed by the entrepreneur and evolves through subsequent generations of the family. Data are gathered by having the key family members from a group of six or seven companies meet once a year to identify key issues and discuss with the faculty and each other how they deal with them.

Professor Van Maanen has approached the problem by studying in detail the cultures of several occupations and organizations such as a police department, a fishing community, a small local business, a railroad yard operation, and developing the ethnographic tools needed for studies of this kind. A particular focus which he, Professor Bailyn, and Professor Schein have developed is to understand the categories by which one analyzes a culture, and the methods one uses to develop that understanding. Several case histories of organizational cultures are currently under way. Two of these cases are in the high-technology industry which makes them particularly relevant to understanding how innovation occurs in society and how the innovative individual, whether engineer or entrepreneur, develops.

2) The Study of Socialization and Career Development. Professors Bailyn, Van Maanen, and Schein have developed an understanding both of the process by which people are brought into organizations and subsequently developed, and the cultural content which is learned during that process. An important continuing focus of this research is to understand the consequences -- what kind of career development for managerial, technical, and professional people leads both to what the organization needs in terms of productivity and innovation, and what the individual needs in terms of life fulfillment.

Professor Bailyn in her prior studies has related how work and family concerns interact throughout the course of life. In her current study of a large complex organization, she focuses specifically on how the organizational culture defines work, career, and advancement in relation to the individual's expectations about these issues. This work is related to the longitudinal studies of Sloan School alumni conducted by Professor Schein to determine how different kinds of careers evolve. The concept of career anchors as a way in which people develop a self concept has proved useful in defining the subjective side of careers.

3) The Study of Productivity and Innovation in the Research Lab. Professor Allen, Dr. Katz, and Professors von Hippel and Roberts from the Management of Technology Group have attempted to approach some of these issues by studying the dynamics of research and development projects

and laboratories directly, focusing specifically on the communication process. Information is the lifeblood of such organizations, so the process by which it comes into groups, circulates, and is utilized is central to group performance. Professor Allen has focused on this process from the point of view of how to organize and structure laboratories. Dr. Katz has studied the effects of group longevity on communication and effectiveness, and both have developed important insights on such matters as whether groups should be project- or function-focused, how long a given group should be kept together, and how best to design the physical facility to maximize the input of technological gatekeepers.

4) The Study of How to Change and Develop Organizations. The fourth focus derives from Kurt Lewin's famous dictum -- if you want to understand something, try to change it. For Professors Beckhard, Leo B. Moore, and Schein and for Dr. Nevis, this dictum has provided an important focus for applied research, consulting, and "clinical" work which reveals dynamics in organizations not otherwise visible. Professor Moore has focused particularly on how to make production work more innovative and effective. Professors Beckhard and Schein and Dr. Nevis have continued to develop the theory of organization development and planned change, and Dr. Nevis has focused on the process of creativity itself through continued work on his "blocks to creativity" program.

All of this work has taken on an increasingly international focus in the effort to better understand what American management methods are and what they can do, relative to the methods used in other societies, especially Europe, Japan, and mainland China. These areas have been systematically visited and analyzed by Professors Beckhard, Allen, and Schein and Dr. Nevis. In the end we hope to clarify the current debate about what is the "best" way to organize or manage.

Employment and Industrial Relations. By far the predominant activities this past year occurred under the auspices of the major research project funded by the Sloan Foundation. The Industrial Relations Section has received a grant of $450,000 (over a three-year period) to examine the US industrial relations system in transition. The premise for this project is that fundamental changes are taking place in industrial relations in this country, and it is a propitious time for documenting and analyzing these changes and emerging trends.

A series of sub-studies has begun, and good progress has been made in linking developments at three levels: corporate strategy, collective bargaining, and plant. For the plant level, Professors Kochan and Harry C. Katz have used thesis material developed by several master's students for the preparation of papers that analyze the performance and impact of quality of work activities at General Motors. For the first time, the implications of quality of work can be evaluated on a quantitative basis. At the middle level of the structure, namely, collective bargaining for the company or industry, Professor McKersie and Peter Cappelli have completed a paper on concession bargaining that tracks the many changes taking place in collective agreements across a number of industries that are experiencing substantial competitive pressures. For the highest level, corporate strategy, studies are under way to unravel the important and complex relationship between corporate strategy and industrial relations policies. Of particular interest is the manner in which a number of large companies have evolved from a state of heavy unionization to one where a majority of the plants are unorganized. Field studies will be conducted this summer and during the next academic year to better understand this important shift.

Related to collective bargaining is Professor Katz's ongoing examination of the industrial relations dimensions of the US automobile industry. Professor Katz is participating in the MIT project on the world auto, and in conjunction with that project he has prepared several papers that have been presented at international conferences this past year. Professor Henry Farber of the Department of Economics continues his work on arbitration procedures and brings his talents in constructing models and analyzing the bargaining process to this important subject.

Several other themes of an important policy nature have occupied the research attention of faculty members in the Section. The theme of productivity has been of concern to Professors McKersie and Barocci. In conjunction with Jan Klein, a Ph.D. student, Professor McKersie has prepared a report for the Committee on Economic Development (CED) detailing the industrial relations dimensions of productivity. The core of the report is based on a survey conducted among 30 CED corporations documenting the causes of the productivity problem and some of the programs being used to deal with the productivity challenge. Professor Barocci has continued his work on quality assurance, and this past spring semester directed a structured thesis seminar that collected extensive information on productivity programs and practices in US industry.

The subject of plant shutdowns and worker displacement continues to be of interest to several members in the Section. Professor McKersie, in conjunction with Werner Sengenberger of Munich, Germany, completed a report for the Organization for Economic Cooperation and Development (OECD) on large-scale workforce displacements. The work of Professor Michael Piore on immigrant labor relates to the theme of economic dislocation. He has analyzed how the labor market works for undocumented immigrants, especially in New York City. He is especially interested in the reemergence of "home work" and other forms of substandard production.

Another theme of considerable importance is that of technology. Professor Piore (in conjunction with Professor Charles Sabel) is working on a book that examines the imbalance between the requirements of new technology and institutional arrangements that are in place, specifically, existing mass production technology, the procedure of scientific management, and union-instituted work rules.

Research work that can be labeled "labor market" in subject matter has been a part of the tradition of the Section from the very beginning. Indeed, some of the classic studies of our field on how labor markets work, both internal to the firm and within the larger community, were pioneered at MIT (under the guidance of Professor, Emeritus, Charles A. Myers). In this tradition, the work of Professor Phyllis A. Wallace on women in the workplace and her ongoing study of Sloan graduates, especially women, can be cited. Professor Wallace was asked to be a scholar-in-residence at Radcliffe this past year, and she presented a seminar on her study of the career experience of Sloan graduates. Professor Wallace has finished her work on the labor market position of special groups such as women and minorities, and Professor Katz has completed his project on the implications of school desegregation for teacher unions. He has completed a project funded by the National Institute of Education (NIE) on interaction between desegregation and labor relations.

On a larger scale, Professor Barocci has completed a review of the activities of the education and training administration of the US Department of Labor. A major chapter evaluating the research work that has been done in this area will appear in a volume to be published by the Industrial Relations Research Association next year.

On a more theoretical level, Professor Farber has completed work on union wages and the minimum wage, job queues and the union status of workers, and worker preferences for union representation. His work represents an imaginative use of economic models and empirical data to test important propositions about labor market behavior.

The newly emerging area of human resources is growing in importance in the research agenda of the Section. Professor Katharine G. Abraham's work on vacancies has been well received and cited in both the popular press and academic journals. She has begun research work on part-time workers, and will continue her investigation into the relationship between performance, pay, and longevity.

The most notable trend on the teaching front has been the steady movement of the standard courses toward a balance between the traditional subjects of industrial relations and the emerging subjects of human resource management. Indeed, most of the core subjects have been relabeled to reflect this, and are now entitled Industrial Relations and Human Resource Management.

We continue to use the bargaining game to involve students in the important learning experience of the bargaining process. Professor Barocci is in the process of putting the game on the computer and developing a series of on-line techniques to enable students to assess various strategic options with more precision and speed.

On other fronts, Professor Katz is involved with an MIT-wide project on the automotive industry, and Professor Barocci is playing a key role in the Center for Information Systems Research, particularly with respect to studying the labor market position of computer professionals. Our connection to the Department of Economics continues to be close, and we value the participation of Professors Piore and Farber in the work of the Section.

Members of the Section continue to be extremely active via professional associations, appearances at conventions, talks before company and union groups, etc. As a partial piece of evidence about the visibility of the Section, nearly every major article on industrial relations in *Business Week* this past year included comments by members of the Section, such as Professors Kochan, Piore, Katz, and McKersie.

In this connection, it is important to note that the professional standing of the Section has been validated as a result of a survey conducted in conjunction with the Behavioral Science Task Force of the School this past year. We consistently were ranked as one of the top three industrial relations programs in the country. This reflects the standing that peers give to the work of the Section. This is not surprising, given the special accomplishments of members such as Professors Kochan and Wallace. Professor Wallace was honored this past year, receiving the Westerfield Award of the National Economic Association for achievement in economics and the minority community at large. Professor Kochan's book was featured in a special issue of *Industrial Relations* that contained a series of review articles about his pioneering book on collective bargaining and industrial relations.

It is also interesting to note that the research volume published this year by the Industrial Relations Research Association had as a coeditor Professor McKersie, and the volume published next year will be edited by Professor Kochan.

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.

During the past year, Institute Professor Franco Modigliani's research activities have been devoted to the preparation of the American Finance Association's Presidential Address which reexamined the core issue of finance -- the effects of financial policy on valuation and on the cost of capital -- but with a new emphasis on the implications of inflation. In addition, he has continued work on a two-year National Science Foundation (NSF) grant focusing on the monetary mechanism in relation to financial structure, aimed at extending the result of earlier work by relaxing the initial assumption of complete price rigidity. He has also continued his interest in the design of mortgages and pension contracts for an inflationary environment. In the fall he contributed to the organization of the Conference on Banking and Industry in the Inter-War Period which was financed by the Banco di Roma and cosponsored by the Sloan School. Professor Modigliani continues to be vice president of the International Economic Association.

Professor Paul R. Krugman has been working on the relationships between technology and international trade. One part of the research has been concerned with the idea of a "technology factor" in international trade. Is there a sense in which we can classify some goods as "technology-intensive," and use this classification to explain trade patterns? The other part of the research is concerned with the effect of trade policy on technological change. In particular, Professor Krugman has worked on the question of whether protection of high-technology industries promotes one country's growth at the expense of others. He also has been serving as a consultant to the National Academy of Sciences, for a study on international competition in advanced technology.

Professor Schmalensee has been studying the electric power industry, concentrating on issues related to regulatory reform. He has conducted an empirical analysis of the competitive implications of deregulation of electricity generation, for which he has developed new methods for assessing the competitive structure of spatial markets. Over this past year he has written on the assessment of market power in antitrust cases, the influence of scale and media mix on advertising agency costs (with A.J. Silk and R. Bojanek), and on the relationship between advertising spending and barriers to entry. He is continuing to study the competitive implications of product differentiation and imperfect information about the qualities of new products.

Professor Thomas M. Stoker's research covered topics in aggregation theory, consumer demand analysis, and nonlinear estimation of econometric models. He developed statistical tests to detect the presence of distributional effects on estimated coefficients of macroeconomic equations, and is currently applying these techniques to analyze consumer demand models and the US income distribution. He also continued work on micro-macro demand modelling. A model was developed which accounts for the use of both broad category and population-averaged expenditure data, and used to study consumer expenditure patterns between energy and non-energy commodities as well as between different types of energy. This study permits the calculation of differing energy price indices for differing families, as well as a detailed characterization of consumer budgeting.

Professor Julio J. Rotemberg has continued his work on macroeconomic models in which agents have rational expectations. He has analyzed the effects of energy price shocks both on aggregate activity and on the demand for capital in the US. He also has studied the extent to which aggregate fluctuations in consumption and employment can be characterized as being the consequence of optimizing behavior on the part of households which face no quantity constraints.

Professor Martin Zimmerman's year has been concerned with the evolution of the nuclear power industry in the United States. Using nuclear power as a case study, he examined the implications of learning for government policy on technology introduction. The results show significant learning effects in the early stages of technology introduction. However, the greatest part is internal to the firm. Externalities are relatively small and government subsidy of commercial scale plants would not have greatly affected industry evolution. He then turned to more recent developments including the impact of the accident at Three Mile Island (TMI) on the evaluation of nuclear power. Using data on utility stock prices and characteristics of the utility's plant and regulatory involvement, he examined which segments of the nuclear power industry were affected by TMI-related developments. His research is now exploring in more detail how the regulatory environment affects utility investment vis-à-vis nuclear power and investment incentives in general.

Professor Robert S. Pindyck has been studying the behavior of the firm and the behavior of markets under various forms of uncertainty. For example, he has examined the ways in which investment behavior is affected by uncertainties over future costs and prices. He also has been concerned with the links between energy markets and the economy, and in particular the ways in which rising energy prices affect economic growth, inflation, and unemployment. Together with Professor Rotemberg, he has developed a dynamic model of the firm's demands for factor inputs (capital, labor, energy, and materials), and used it to study the effects of an energy price shock on investment, employment, and energy use. Finally, Professor Pindyck has continued his research on the economics of natural resource markets and has written a paper examining the behavior of a renewable resource market when there is uncertainty over the biological growth process.

Professor Edith 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 strategic 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. Professor Welsch, William Krasker (Harvard), and Professor Kuh have contributed on a chapter to "The Handbook of Econometrics," Vol. I, North Holland (to be published) on robust regression estimation. These methods restrict the allowable impact of influential data on coefficient estimates.

Professor Thurow is in the process of completing a book on the intellectual currents of economics. The book seeks to examine why economics is moving in its current direction and to look in detail at monetarism, supply-side economics, rational expectations, econometrics, and labor economics. He continues as columnist and contributing editor for *Newsweek* magazine.

Professor Sidney S. Alexander was on full-time leave during the fall semester of the academic year 1981-82 and on half-time leave during the spring semester. His principal activity during the spring semester was the preparation of a new treatment of the subject of international economics for management. He also has been working on the foundations of normative judgments of social policy.

Professor Ernst R. Berndt's research, supported in part by the National Science Foundation, the US Department of Energy, and the Mexican government, focuses on the technical-engineering characteristics of energy-using capital plant and equipment, and the evaluation of these capital assets by consumers and the securities market. Studies are under way dealing with effects of unexpected energy price increases on the economic (as distinct from technical-engineering) depreciation of durable assets such as trucks, tractors, and automobiles in the US, Sweden, and France; and the extent to which consumers' evaluations of innovative design combinations (new durable good products) are manifest in second-hand markets for goods embodying alternative technical-engineering design configurations.

Professor Fischer Black's paper on econometric models was published this year. It suggests that econometric studies tell us much less than is generally supposed; i.e., they can tell us about correlation (statistical structure) but not about causation (economic structure). The informal version of his paper on business cycles has been published, while the formal version is still in progress. He treats business cycles as a natural result of freely operating markets for goods and services and for capital and labor. He has completed a working paper giving a simple way to discount corporate cash flows, and a working paper that shows how the US could operate a gold standard without the disadvantages that many economists cite.

Professor Daniel M. Holland's work has been primarily in two parts; the first, research on corporate profitability and investors' returns, undertaken together with Professor Myers, is in its final stages. He is preparing a volume incorporating their work on the US, the results of similar inquiries in six other countries, and a summary chapter. The second relates to the impact of Proposition 2 1/2. He has started a study of the employment of user fees and charges in Massachusetts, and changes therein in response to Proposition 2 1/2.

To estimate the underlying "trends," we have a 10-year run of data for all cities and towns in the Commonwealth from the Governments Division of the Bureau of Economic Analysis of the Department of Commerce. With this benchmark, they will compare the experience in the two years immediately following Proposition 2 1/2. Through interviews with officials and other employees in selected cities and towns, they also intend to study the decision to employ user charges and their implementation. Professor Holland expects this work to continue over the academic year 1982-83 and into the following year.

Professor Lessard has been involved in three research projects this year. The first has been a study of the costs and implications for managerial behavior of alternative financial incentives provided by governments to induce firms to invest in particular regions or projects or to bail out troubled firms. The financial incentives studied include loan guarantees, concessional loans, and a variety of tax abatements. Because such incentives involve future, contingent payments, they usually escape security in budgetary analyses which focus on cash expenditures. Further, because the payments are often contingent on corporate failure, they are most attractive to risky, thinly capitalized firms and tend to encourage recipient firms to select relatively risky projects and to abandon such operations if they encounter further troubles, thus often defeating the purpose of the government intervention, e.g., the creation of permanent jobs.

Together with Professor Carliss Baldwin and Professor Scott Mason of the Harvard Business School, Professor Lessard has outlined an approach for calculating the cost grant equivalents of various incentives and capturing these cash grant equivalents in budget allocations. This research has been sponsored by the Corporate Finance Division of the Department of Finance of Canada. One working paper has been completed -- "Controlling Indirect Financial Subsidies in Canada's Budget: Diagnosis and Recommendation," SSM Working Paper #1302, April 1982, another is in preparation, and a book-length monograph including a series of case studies is planned.

The second project has been a study of the role of sovereign risk or country risk in limiting the degree of international financial integration. All available evidence suggests that international ownership of financial claims is far smaller than predicted by financial theory in the absence of barriers to international investment, and risks of a political nature appear to be among the most important barriers. The research has consisted primarily of attempts to define country risk and to trace through the various ways in which it can inhibit cross-border investment. Further research is planned on the effect of country risk on capital market equilibrium and the structure of social discount rates in small countries whose theoretical determination rests heavily on the impact of country risk on the supply of foreign funds.

This research was part of a larger study of US policy consideration in the international financial system under a competitive planning grant from the NSF.

The third project was a study of financial and political considerations in contracting for natural resource exploitation in developing countries. It is described in the discussion of research in the International Management Group.

Professor Terry A. Marsh's intended summer research is in three parts. The first is the preparation of one paper from his dissertation for journal submission. The paper is concerned with the empirical fit of various (increasingly sophisticated) capital asset pricing models. The assets

whose prices are studied are government bonds of various maturities so that, in effect, the paper is also concerned with the term structure. He has reformulated some tests and will be doing considerable additional empirical work.

The second part is a preparation of a research proposal to Columbia University's Center for Study in Futures Markets Research on the impact of market microstructure on the properties of transaction-to-transaction prices in those markets. He has collected a set of data on Hong Kong and Tokyo futures markets which, along with some Chicago Board of Trade data, will be used in this research.

The third is a revision (but not submission) of a draft of his "Accounting and Economic Earnings" paper, and of a draft of an "Equilibrium Bond Pricing" paper with Professor Eric Rosenfeld at Harvard.

Professor Robert C. Merton has continued his research in finance and economics in the areas of capital markets, asset evaluation, information evaluation, and corporate liabilities pricing. Specific areas studied include the analysis of private and public pension plans, the evaluation of options on fixed-income securities, and a theoretical analysis of the market-maker function. He also has continued his studies of the reward system for scientific research. He has received support for his research from the NSF and the National Bureau of Economic Research.

Professor Myers has pursued long-term research interests in the general areas of capital markets, corporate finance, and regulation. Previous work on stock issues and investment policy under asymmetric information was extended to the choice of debt vs. equity financing. A paper on inflation and rate of return regulation, which proposes a new regulatory system based on trended original cost rate leases, was revised and extended. He continued to work with Professor Holland on measuring profitability and capital costs of US corporations. In addition, preliminary planning was done for a major research project on corporate capital budgeting procedures.

Professor Richard S. Ruback completed a paper entitled "Effects of Nominal Contracting on Stock Returns" (coauthored with Kenneth French and G. William Schwert) which has been accepted for publication in the *Journal of Political Economy*. The paper examines the effects of unexpected inflation on the common stock returns of companies with different monetary positions and different amounts of nominal tax shields. He also completed a detailed study of the merger between duPont and Conoco which appeared in the Winter 1982, *Sloan Management Review*. The second draft of "Assessing Competition in the Corporate Acquisitions Market" was completed and presented at the Seminar on the Analysis of Security Prices in May 1982. The first draft of a paper coauthored with Professor Baldwin entitled "Inflation, Discrete Replacement and the Choice of Asset Lives" was completed in the fall. This paper is currently under revision and was presented at the Western Finance Association meetings in June 1982.

Management Science

Academic year 1981-82 marked the 10th year of the Management Science Group. The decade has been one of change, growth, and accomplishment. A diverse faculty, mostly assistant professors, has become much more balanced across ranks and far more effective and influential in research, professional activities, and societal affairs.

The early 1970s witnessed a period of considerable public reservation about science and technology, and these concerns extended to quantitative approaches to management. In recent years, however, the shocks of the oil crisis, international competition, and economic sluggishness have heightened interest in productivity and managerial effectiveness. Coupled with the desire for better performance has been a widespread perception that our society stands on the threshold of a "second industrial revolution" in which computers, data, and telecommunications seem likely to transform the way organizations and the people in them function. If this is indeed to take place, much new effort will be required to determine what computers will be doing with what data and who will communicate information to whom. Such questions involve models, measurements, and information systems that are central concerns of the faculty of the Management Science Group.

As an example, the marketing faculty within the group have been working to develop new understanding of marketing processes and to use such knowledge for improving marketing productivity. Professor Bagozzi has been studying attitude formation and its impact on intentions and behavior. Professors

Urban and Hauser are working on a measurement and model system to forecast demand for new consumer durables, such as automobiles, before they are put into production. Individual choice behavior is central to marketing processes, and within this framework Professor Leigh McAlister is investigating the variety-seeking behavior of consumers and its implication for marketing policy. Professor Silk continues his work on assessing the psychometric properties of measurements commonly used in marketing research. Utilizing data which are becoming widely available from the optical scanning of goods at supermarket checkout, Professor Little has been building models of market response to price and promotion.

Of immediate national concern is the need for greater productivity in operations management and a longer-range view for corporate planning. Professor Hax has built an extensive conceptual and empirical foundation for the design and implementation of formal strategic planning systems. Professor Graves has developed and applied a number of production and inventory control models including one with Senior Lecturer Meal for an integrated-circuit manufacturing process. Related research is being conducted by Professor Bitran on flexible production systems.

The time-honored fields of accounting and control are undergoing changes as new technology emerges. Senior Lecturer McInnes has studied the design and implementation of computer-based corporate planning models in a group of 21 companies. A new methodology called data envelopment analysis has been used by Professor Sherman for evaluating the performance of service organizations, such as banks and hospitals, which have multiple outputs and inputs but lack well-defined production functions. The research of Professor Brownell has indicated that broad managerial participation in the budgeting process, widely considered desirable, will be ineffective unless accompanied by appropriate leadership styles in the work groups involved. Professor Ram T. S. Ramakrishnan continues his research using agency theory to study management control, particularly with respect to the role of information and individual incentives.

As mentioned earlier, the computer and telecommunications technology indicates great change for management. The Center for Information Systems Research is on the forefront of new developments. Its director, Senior Lecturer Rockart, and Assistant Professor Michael Treacy have produced an important study on computer support for top executives. Dr. Rockart's work on the critical success factors method for information systems analysis continues to gain application.

Professor Scott Morton, who coined the popular term "decision support systems," has embarked on a new line of research related to corporate strategy. The important interface between computers and law is the subject of Professor Meldman's current work. Professor M. Lynne Markus is studying the impact of information systems on organizations. Professor Keen, besides his work on decision support systems, has started a study of human resources policy analysis in the computer field.

Professor Madnick's research on database computers seeks to extend their capability by a substantial factor. The explosive area of microprocessors and personal computing is being addressed by Professor Hoo-Min D. Toong.

Public policy issues continue to command attention. Professor Henry D. Jacoby, chairman of the Operating Committee of the Center for Energy Policy Research, is studying world oil markets, particularly focused on cartel behavior. Senior Lecturer David O. Wood has been program director for the Studies in Energy and the American Economy program. Professor Gordon M. Kaufman has completed a large-scale study on the estimation of energy reserves and resources. Professor Arnold I. Barnett continues his work on mathematical models for analyzing a variety of aspects of the criminal justice system.

Methodological advances, particularly in optimization and statistics, are necessary to support management science research in contextual areas. Network optimization is the focus of current research being conducted by Professor Thomas L. Magnanti. Professor Orlin has been analyzing particular combinatorial optimization problems in scheduling that are well known to be difficult, and is developing new approaches to solving them by seeking "almost optimal" formal solutions. Further basic research in mathematical programming, in this case into "inverse" optimization, is under way by Professor Shapiro. Professor M. Anthony Wong has continued to develop statistical clustering procedures and applied them to such diverse problem areas as marketing and medicine. The ongoing research of Professor Welsch in statistical diagnostics has been focused on finding ways to detect influential subsets of data and model failure.

Several honors and distinctions came to members of the group during the year. Professor Magnanti was appointed the next editor of *Operations Research*. Professor Barnett was one of eight individuals cited in a *Fortune* article on favorite business school professors. Professor Bagozzi's year of study in West Germany was the result of a Fulbright award. Professors Little and Silk, along with coauthors at AT&T, were winners of a Management Science Achievement Award from the Institute of Management Sciences for their paper, "The Development, Testing, and Execution of a New Marketing Strategy at AT&T Long Lines."

System Dynamics

The System Dynamics Group incorporates four areas of activity -- teaching, application of system dynamics to corporate policy, the energy transition from petroleum to other energy sources, and national economic behavior.

The System Dynamics National Model. The System Dynamics National Model is being developed to achieve a more unified understanding of social and economic behavior. The work is directed by Professor Jay W. Forrester, Germeshausen Professor of Management, along with Professor Senge and Dr. Alan K. Graham. The National Model and its applications are supported by some 40 sponsors, mostly from the private sector (corporations, foundations, and private individuals), with participation from state, US, and Canadian government agencies.

The System Dynamics National Model is a computer simulation model for investigating how parts of the socioeconomic system interact to produce macroeconomic behavior, and for helping to choose policies for a more desirable future.

The National Model is intended to provide a general conceptual framework for understanding economic dynamics and national policy. The Model contains industrial sectors for consumer durables, capital equipment, and energy. Each industrial sector of the Model is constructed to represent a typical business firm in that sector of the economy. Each sector acquires employees and capital plant on the basis of return on investment, order backlogs, inventories, prices, costs, growth rates, marginal productivities, liquidity, profitability, and regulatory constraints. Each production sector contains a full accounting system that handles accounts payable and receivable, generates a balance sheet and profit-and-loss statement, pays taxes, and borrows money. The Model also represents the movement of people between sectors, a banking system, the Federal Reserve, a government sector, and household consumption.

The System Dynamics National Model differs substantially from the more common econometric models. Econometric models are derived from statistical summaries of aggregate economic behavior, whereas the National Model reflects the operating structure that affects actual decision making. The National Model is built up from governing policies that have been observed and studied in corporations and households. The National Model shows how microeconomic processes of individual decision making interact to produce overall macroeconomic behavior. The National Model also differs in its basic purpose from econometric models, which are primarily intended for short-term forecasting. The National Model is intended for understanding the causes of economic behavior and for evaluating alternative national policies.

The Project is expected to draw together diverse viewpoints on economic behavior. Current debates on economic policy are frustrating because there has been no way to resolve opposing viewpoints. Debates focus on competing theories of inflation or economic stagnation with little recognition that opposing theories often simply emphasize different parts of the economic system. By providing a broader view capable of interrelating different theories, the National Model is becoming a new tool for increasing consensus on key national issues. Moreover, because the Model can yield clear, understandable explanations of current problems, the resulting consensus can include a broad segment of the public. Such public consensus is necessary if we are to establish sound economic policies for the future.

The System Dynamics Energy-Economy Model. The United States is in the midst of a major energy transition. The transition away from dependence on fossil fuels is analogous in some regards to past transitions away from dependence on wood and coal as dominant sources of domestic energy. However, the present energy transition is unique in that it may be the first transition in US history to much more expensive energy sources. The duration of the present energy transition may be considerably longer than is widely expected. The current set of national energy policies may lead to an energy transition that is not complete until well into the first third of the 21st century.

The long duration of the energy transition leads to major questions regarding economic and political vulnerability during the coming 20 to 40 years. The MIT energy-economy study defines economic vulnerability as the extent to which US economic performance can be influenced by interests outside the country. Political vulnerability relates to the loss of self-determination in international and national political affairs.

Although other analyses have attempted to explore economic vulnerability questions associated with the energy transition, the System Dynamics Energy-Economy Model developed by Professor John D. Sterman represents a new tool for energy policy analysis. The Model integrates energy supply and demand within a complete, dynamic macroeconomic framework. Consequently, the Model's estimates of the duration of the energy transition are more realistic than those based on simpler models.

The duration of the energy transition and the vulnerability of the economy during the transition can be strongly influenced by national policies. Analysis based on the System Dynamics Energy-Economy Model suggests that the mix of backstop-energy technologies can significantly influence the duration and severity of the energy transition. Technologies that have long lead times and highly capital-intensive production, such as are currently favored in national policy, are not optimal from the standpoint of reducing vulnerability. The transition can be improved considerably by greater reliance on "unconventional" backstop technologies. The primary characteristics of effective unconventional backstops are 1) shorter lead times, 2) more labor-intensive means of production, and 3) greater decentralization so as to require less costly reallocation of labor resources.

System Dynamics Corporate Research Program. Professor Morecroft has established the System Dynamics Corporate Research Program. The program focuses on the application of system dynamics to business policy and strategy development. It is currently supported by a group of five corporate sponsors and provides applied research opportunities for graduate students in the Sloan School. The program also provides a broad empirical base to support more general business policy research. Work in this area involves the study of generic feedback structures arising in business administration that underlie a wide range of managerial problems.

System Dynamics Teaching. Finally, we have continued to develop our teaching programs in system dynamics in the Sloan School. Subject 15.874 has been renamed System Dynamics for Business Policy (instead of Industrial Dynamics) to reflect the policy emphasis of the subject material and to underscore the relevance of the subject in a general business education. Subject 15.875 Applications of System Dynamics has continued to evolve as an effective experience for students in real-world policy analysis. Over the past year, five local companies agreed to participate in semester-long applied research projects and to provide financial support to the System Dynamics Corporate Research Program. Two of the student teams assigned to these projects have been able to use their work as a basis for master's dissertations with publication potential.

Management of Technological Innovation

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, replicating his earlier research on Ireland. Plans are now under way to expand the Swedish petrochemical industry. The work complements domestic studies done in collaboration with Dr. Katz on communications into and within long-range research and development (R&D) groups. Data analyses of more than 250 project teams are now aimed at explaining the "not-invented-here" syndrome and its effects upon technical obsolescence.

Dr. Katz also is researching engineering supervision in a joint study with Professor Michael Tushman of Columbia University, who will join us next year on a visiting basis, and has an ambitious investigation under way on project management in 100 matrix team organizations. Dr. Katz has combined these studies well with his other longitudinal research of young engineers as well as nontraditional professionals.

Professor Dorothy Leonard-Barton has extended her prior research interests on the nature of social and technological diffusion processes into more general aspects of transfer technology. In one project she is examining the acceptance of both radical and incremental innovations among dental specialists, with expected generalizations to other fields. In this, as well as in two other research projects, Professor Leonard-Barton emphasizes interpersonal aspects of technology movement. Another study, newly underway, focuses on inter-organizational transfer of new technology, specifically from MIT to industry in the biomedical area.

Professor Roberts has continued his research studies on technology-based company founding and growth. Seven related thesis studies gathered data on new Massachusetts companies, their entrepreneurs, and managerial processes, as well as explored venture capital investments and the financing of high-technology firms. Another effort in collaboration with Professor Leonard-Barton and with Professor Utterback of the School of Engineering compares success factors affecting US technical firms with similar Swedish companies. Professor Roberts also has initiated other research projects on the generation and commercialization of health technology, as reported in the Health Care Management section of this report.

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 his earlier research on the role of users in generating innovations, especially in the area of industrial goods. He is now writing a book which describes his several years of research studies on the locus of technological innovation.

Professor Finkelstein significantly expanded his research studies on the acceptance, evaluation, and consequences of emerging medical technologies. His work is described in greater depth in the section of this report on Health Care Management.

Expansion of subject offerings continued during 1981-82 with the introduction of the several new subjects needed for the new Joint Master's Degree Program in the Management of Technology. For the first time, Dr. Katz introduced Managing Professionals; Professors von Hippel and Urban jointly developed and taught Technology/Marketing Interface; and Professor Allen taught Technical Problem Solving and Communications. These new subjects were well received not only by students in the Joint Program but by other graduate students in the Sloan School and the rest of MIT. In addition, fostered by Joint Program relationships, Professor Raymond Baddour of the Department of Chemical Engineering collaborated with Professor von Hippel in a revised New Technical Ventures subject. The 10-year cooperative effort continued between the David Sarnoff Professors of MIT and Harvard Business School, with Professor Richard Rosenbloom of HBS and Professor Roberts examining international dimensions of corporate research and development strategy and organization.

Professors Ching-rui Xu of the People's Republic of China and Paul Roy of Laval University in Quebec contributed to the area activities during the past year as distinguished visitors.

Corporate Strategy, Policy, and Planning

The group has been very productive in research during the past academic year, building a solid foundation for the future.

Professor Louis L. Banks has been concerned with the social values of firms, how these originate, and how they propagate within organizations.

Professor William F. Bottiglia continues his work on the philosophy of civilizations. This is a multivolume effort.

Professor Bowman's main research thrust has centered around the relationship between risk and return for successful and troubled firms. He also is studying the characteristics of strategic planning processes of manufacturing organizations.

Professor Horwitch's work on the SST was published by the MIT Press. He is now focusing his research on revitalized industries and a comparison of the strategies of such industries with those applied within the semiconductor and biogenetics industries.

Professor Scott Morton, a new member of the group, has been concerned with the elements of the strategic planning process and the impact of the new telecommunications technology on the strategy of firms.

Professor Walker is completing his research on the impact of inter-organizational relationships of effectiveness. He is gradually shifting his research focus on the implications for business strategy of industry market and business definition.

Professor Zannetos continues his multifaceted research in the areas of 1) strategies for productivity and innovation; 2) rational vs. behavioral theories of the firm (management of complexity and the impact on organization structures, definition of constituencies and environmental search, rational expectation, price-elastic expectations); and 3) the economics of oil transportation and oil pricing. Seven papers resulted from some of this research, with two more in process. The research is at a critical turning point and the need is evident for a more concentrated effort (research seclusion).

International Management

Professor Lessard has been doing research in three areas bridging finance and international management. The first two -- the evaluation and control of indirect financial incentives and the impact of country risk on international financial integration -- are described earlier in the discussion of research in the Finance Group. The third area has been a study of financial and political considerations in contracting for natural resource exploitation in developing countries. In much of the literature this issue is viewed as one of zero-sum negotiation, where the gains to one part represent losses to the other. However, there are a number of ways to structure contracts which are mutually beneficial because of the comparative advantage of firms based in world capital markets in bearing output and price risks relative to countries which depend on a specific commodity for a significant proportion of their exports and government revenues. In designing appropriate contracts, however, several often conflicting considerations come into play. These include incentives for appropriate managerial choices, the credibility of the contract, and the avoidance of double taxation in the case of firms based in countries which tax global income.

Together with James Paddock and Charles Blitzer of the Center for Energy Policy Alternatives, Professor Lessard analyzed a variety of generic contract forms from the perspective of a particular oil-exporting country. These analyses included a simulation of the impact of geologic and market risk on the allocation of returns between the country and the contracts.

This research also formed the basis for a thesis workshop involving 14 S.M. students. The topics of the theses included the financial evaluation of recent oil exploration and development contracts in Greece, Brazil, China, and Norway; the evaluation of various proposed schemes for Ecuador; the private and social evaluation of copper mining in Peru; and studies of political risk and the social discontent rate as applied to minerals projects. Summaries of these theses will be included in a book-length report to be issued jointly by the Center for Energy Policy Research and the Harvard Institute of International Development.

Professor Robinson has been involved in three research projects during the year. The first has been a study of the Japanese managerial system, how it is changing, and how it impinges on the performance of US firms taken over or newly established in the US by Japanese companies. The study began with a preliminary inquiry in Japan during the summer of 1981, during which Professor Robinson undertook to interview approximately 80 Japanese executives and knowledgeable academicians. The second phase of the research was launched during the fall of 1981 with a seminar for 10 master's students who chose to write theses based on a study of selected firms in the US which the Japanese had either established or acquired. The seminar was designed to convey the insights collected during the summer's research in Japan and to generate the sample and methodology for the US study. The 10 students began their fieldwork in the late fall and continued through the winter; 60 to 80 interviews were conducted in approximately 40 companies scattered across the US, the results of which have been reported in nine theses (one was jointly authored by two students). A preliminary report on both phases of the research was given in an ILP symposium by Professor Robinson in April, a version of which is planned for publication in *Technology Review*. A book-length analysis will be prepared early next year.

The second project was based on interviews in 51 US corporations conducted by Professor Robinson and a student assistant in order to ascertain the impact of government incentives (US and foreign) on US corporate decisions to invest abroad. Special attention was given to investment decisions relating to the lesser-developed countries. The purpose of the project, which was funded by the Overseas Private Investment Corporation (OPIC), was to ascertain the cost-effectiveness of various investment promotion programs. This study will result in the publication of a book-length report, presumably in early 1983.

The third project has been a study of behavior of four international corporations in order to establish their track records in the areas of political involvement, sensitivity to host governments and local societies, and social issues.

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 research in areas related to the development and dissemination of health technology. With funding from the Department of Health and Human Services, the Health Care Financing Administration, and the MIT Whitaker College Program in Health Policy and Management, Dr. Finkelstein has been investigating the impact of randomized 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 an empirically supported 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 Finkelstein developed a major research proposal, involving broad MIT faculty participation, to examine the relationships between medical evidence and clinical practices. Efforts continue to fund this multi-year, multi-investigator research program.

Professor Roberts has continued 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. This effort has been funded by a grant from the Kaiser Family Foundation for the Whitaker Program in Health Policy and Management. The second examines the commercial development stage of health research results, contrasting the roles of new and older companies in the areas of drugs and medical devices.

Efforts last year by Professors Roberts and Finkelstein in convening a major conference sponsored by the National Institutes of Health have resulted in an important new MIT Press book, *Biomedical Innovation*, that documents the state-of-the-art of managerial and policy knowledge of the medical innovation process. Professor Finkelstein, in collaboration with Professors Alvin Drake of the Department of Electrical Engineering and Computer Science and Harvey Sapolsky of the Department of Political Science, has completed another book, *The American Blood Supply*, to be published by MIT Press this summer.

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 Whitaker College. Professor Roberts chairs that interdisciplinary program, which was launched with a major dedicatory symposium on health policy in March.

Dr. Norman S. Stearns, associate dean of the Tufts University School of Medicine, continued as a visiting professor of Health Management and helped lead the year-long seminar in Health Management as well as providing valuable career counseling to students in health-related careers. At year's end, with support of a grant from the Whitaker Program in Health Policy and Management, Professor Stearns initiated a research study on the characteristics and effectiveness of lay vs. physician hospital administrators.

As reported under Management of Technological Innovation, Professor Leonard-Barton, supported by the Whitaker Health Sciences Fund, carried out field research on the diffusion of dental innovations. With a new grant from the Whitaker Health Policy and Management Program, she is initiating research on the transfer of MIT's biomedical research results to industry. Professor Sherman has initiated research on hospital cost measurement systems, aided by a grant of the Whitaker Health Sciences Fund.

EXTERNAL RELATIONS

This administrative area has continued to develop new and more reliable systems to assist the School in being effective and productive in its dealings with alumni and with the MIT Alumni Association.

There has been an enormous increase in update information from our alumni during 1981-82. We received approximately 3,000 changes in either position, marital standing, or home and business address. Our office is now able to assist the computer facility in inputting this information, thus making our records more reliable than in the past.

We also have devised a system that prevents our losing track of alumni, which decreases the number of "unknowns" in the records.

A new directory was prepared and mailed to our master's and Ph.D. alumni in March, and for the first time only one error was reported by an alumnus. We offered this new directory to our graduating classes in these programs, and the response was excellent.

In spite of the state of the economy, contributions have kept pace with previous years. As of June 3, 1982, we received a total of $300,682 in gifts from alumni. Of that amount, $47,838 is from life income gifts. We plan to stress matching gift participation to our alumni during the coming year which, we hope, should increase the amount of gifts.

A new association of master's and doctoral program alumni was formed this past year. The first meeting of the elected officers and governors of this new Graduate Management Association will be held on July 1, 1982, at the Sloan School.

The School's external relations activities have continued to make progress during the year. We have stepped up our alumni relations and our resource development activities, and we look forward to a busy and challenging 1982-83 academic year.

STAFF CHANGES, PROMOTIONS, AND VISITORS

On September 1, Alvin J. Silk, Professor of Management Science in Sloan's marketing area, was appointed Associate Dean of the Sloan School. Dean Silk has been on Sloan's faculty since 1968 and has served on numerous School and Institute committees, in addition to teaching and conducting research in his field. He succeeds Abraham J. Siegel who became fourth Dean of the Sloan School on June 1 after serving as Acting Dean for the previous year.

During the past year, two faculty members were promoted to the rank of associate professor. Martin B. Zimmerman, after working as a research associate and then a lecturer at Sloan, joined the faculty as assistant professor in 1977 in the economics area. Stephen C. Graves also joined Sloan's faculty as assistant professor in 1977. He teaches in the operations management area of the Management Science Group.

John B. Sterman and Gordon B.M. Walker joined the Sloan School faculty as assistant professors. Professor Sterman received his Ph.D. from Sloan and had worked as a research associate in the System Dynamics Center since 1978. Professor Walker, who received his Ph.D. from the Wharton School and most recently was instructor at LaSalle College, joined Sloan's policy and strategy area.

Five faculty taught at Sloan as visiting professors. This year Peter K. Manning, professor in the Departments of Sociology and Psychiatry at Michigan State University, spent the spring term as visiting professor in the organizational studies area. Shan Cretin, who received her Ph.D. from MIT's Operations Research Center, rejoined them as a visiting associate professor for the spring term while on sabbatical from the University of California at Los Angeles. Leigh McAlister, Philip A. Dover, and Sushila Rao joined the marketing area as visiting assistant professors. Professor McAlister, at Sloan for the entire year, is on the faculty of the University of Washington. Professors Dover and Rao, both at Sloan for the spring term, come to us from Amos Tuck School and Boston University, respectively.

Sloan School appointed two new lecturers during this year. Irwin Tepper was associated with the finance area, and E. David Wanger taught a subject in labor law.

We were pleased to host several new visiting scholars and guests of the Institute. Manfred H. Gilli, Koukyu Kawabata, and Louis Lefeber were visitors to the Center for Computational Research in Economics and Management Science (CCREMS); and R. Joel Rahn and Qifan Wang worked with the System Dynamics Center. John M. Stopford and Pan Zhang were associated with the international management area. Barbara Czarniawska visited the organizational studies area, and Philip B. Beaumont joined the manpower and labor relations area. Guoxiang Liu was a visiting scholar in the operations management area. Francesco Favotto was affiliated with Sloan as a guest of the Institute.

The research affiliates during this past year included John Kirsch (CCREMS), Jay A. Kurtzman (Center for Information Systems Research), Moira Hart (labor relations), and John Lynch (organizational studies). David A. Belsley, previously a visiting professor, transferred to the sponsored research staff at CCREMS. Amar Gupta, formerly a research fellow, became a postdoctoral associate in the management information systems area, and Peter H. Cappelli was appointed a postdoctoral associate in the manpower and labor relations area.

On leave of absence this year were Richard P. Bagozzi and Jawaid A. Ghani. Professor Bagozzi spent the year in Germany as a research scholar under the Fulbright-Hays Program. Professor Ghani spent the year in Pakistan developing and teaching the use of decision-support systems for policy making.

On sabbatical this year were Professors J.D. Nyhart (fall and spring terms), Phyllis A. Wallace (spring term), and Daniel M. Holland (spring term). Professor Nyhart spent part of the year as a member of the faculty of law and a visiting fellow of the Centre of International Studies at Cambridge University. Professor Wallace continued her research on employment discrimination and upward mobility of women in management while serving as distinguished scholar in residence at Radcliffe. Professor Holland continued his work on the International Comparison of Rate of Return Project.

Two Sloan School employees were promoted to administrative staff. Josephine DiCicco was promoted to fiscal office manager and Donna Behmer was promoted to operations coordinator. James T. Gabbert, formerly coordinator for the Ph.D. program, became coordinator for the master's programs. Vivian Unterweger began work as the assistant director of finance and administration.

We note with regret several departures from Sloan. These include John F. Collins, consulting professor; James W. Driscoll, assistant professor; Nathaniel J. Mass, associate professor; and Michael Van Breda, assistant professor. Departing staff members include Pamela W. Turner, director of external relations; and Peter P. Gil, associate dean of external relations. Dean Gil is serving as the first dean of the new Graduate School of Management at Clark University. Professor Leo B. Moore, after many years of fine service to the School, has retired.

Finally, we record with sadness the death of our colleague, William A. Martin. At the time of his death, Professor Martin held a joint appointment with Sloan and the Department of Electrical Engineering and Computer Science; he was promoted posthumously to the rank of full professor.

ABRAHAM J. SIEGEL

School of Science

This is my first report to the President since becoming Dean of the School of Science in March 1982. I would like to take this opportunity to acknowledge the accomplishments of my predecessor, Robert Alberty, who has returned to teaching and research in the Department of Chemistry. Throughout his 15 years of service Dean Alberty labored wisely and effectively in communicating the views of the School of Science to the MIT administration and the decisions of the administration to the School. We are all fortunate who benefited from his excellent service to MIT. The School of Science celebrated Dean Alberty's departure from the Dean's Office with a fitting special lecture in his honor, on the occasion of the School of Science's 50th anniversary. The lecture was delivered by Professor George Pimentel of the University of California at Berkeley.

The new Dean does not intend to change dramatically the procedures or operations of the School of Science. There will, of course, be some changes that reflect differences in style but perhaps more importantly, reflect the emergence of new opportunities and needs.

One noteworthy change which has occurred is the assignment of the responsibility for three outstanding MIT laboratories to the School of Science. These are the Center for Cancer Research, the Center for Space Research, and the Laboratory for Nuclear Science. These laboratories are appropriately considered part of the School of Science because they undertake most, but not all, of their efforts with faculty and students from the School of Science. The three laboratories will be a welcome addition to the other interdepartmental activities of the School.

Since it is my first year as Dean, it is appropriate for me to state some of the goals I hold for the School of Science. These goals are mostly quite evident, but this does not make them less valid; I intend that they guide my efforts during the coming few years.

First, the quality of teaching, especially undergraduate teaching, and research must remain our paramount objective. Constraints on available resources will require decisions to be made between competing worthy projects and programs. Demonstrated quality performance and promise will determine the allocation decisions accompanied by the recognition that spreading scarce resources too broadly will not foster excellence anywhere.

In sum, difficult resource decisions will have to be made. In this context, the process for reaching such decisions is most important. I intend to rely heavily on Science Council, occasional ad hoc faculty committees, and the established Advisory and Visiting Committees in making these decisions. Individual faculty, staff, and students are also urged to make their views known directly to me in matters they consider important.

Second, the distinctions between science and engineering, basic and applied research, and academic and industrial research are becoming progressively more blurred in many areas of importance. Examples include biotechnology, high-energy physics, and astronomy. It should be expected that the School of Science will remain active in many collaborations that lead into broader areas of technology. These collaborations take place with other Schools and interdepartmental laboratories at MIT, with national laboratories, and with industry.

Third, the principal responsibility for intellectual matters and for management at MIT rests with department and laboratory heads. This has proved to be a great strength of the Institute, and as Dean (and former Head of the Department of Chemistry) I see no reason to modify this pattern. It does permit me to focus some attention on several major issues that are, in my judgment, of long-term importance to the School of Science. Examples of these issues are:

- the over-dependence on soft money for academic year faculty salary support,
- the high cost of undertaking research at MIT relative to other private and public universities,
- the provision of additional general funds to support undergraduate education initiatives,
- the high cost of graduate student research assistantships,
- identification of new sources of private funds for ongoing support of research activity in the School, and
- achievement of greater participation of outstanding qualified women and minority individuals in the faculty and staff of the School of Science.

It is certain that resolution of these issues will not be easy or quick. Yet I am sure that almost all the faculty of the School recognize that progress on these issues is vital if we are to maintain excellence at MIT. I will report any progress on these issues in future reports.

Academic Programs

There were 737 undergraduates in the School of Science during the past academic year, approximately a one and one-half percent decrease from the previous year. This was the smallest decrease in the number of students since the decline of science undergraduate majors began a decade ago. Twenty-two percent of the Institute's upperclass undergraduates were enrolled in the School of Science.

Graduate enrollments in science decreased slightly from 1,114 in the 1980-81 academic year to 1,110 in the 1981-82 academic year. This represents approximately one-quarter of the total graduate student population at MIT. For the past two years the graduate programs have prospered, thereby attaining the largest number of graduate students in the School for well over a decade. Since the primary source of support for science graduate students is research assistantships, the increase in the number of graduate students reflects the faculty's success in raising the School's research volume.

The faculty size in the School was relatively constant until two years ago when it began to grow by approximately two percent each year. This past year there were 287 faculty members in the School. The undergraduate student-to-faculty ratio was 2.6 to 1, and the graduate student-to-faculty ratio was 3.9 to 1. In general, the School-wide ratios were within a desirable range.

This year the School of Science presented several programs to introduce freshmen to the School. "Science Spectacular," held in the fall, provided a forum for several faculty members to talk about their current research. During the spring semester, "Science Careers," a program designed to explore career opportunities in various fields of science, was presented. In addition, the departmental open houses for freshmen continued.

The Core Group, chaired by the Dean, met several times during the year to discuss Science Requirement subjects and to suggest possible improvements in the Core curriculum. This group consists of approximately 20 faculty members who teach the freshman Requirement subjects, and a number of others interested in freshman instruction.

Research

The research volume of the School of Science in fiscal year 1982 was estimated to be $69,300,000, a 10 percent increase from fiscal 1981. Research activities for the interdepartmental laboratories which report to the Dean of Science were included in the estimate.

Edwin C. Whitehead formed the nonprofit Whitehead Institute for Biomedical Research to pursue independent basic research in developmental biology. Professor David Baltimore, American Cancer Society Professor of Microbiology, is director-designate of the Whitehead Institute. The School of Science anticipates a productive relationship with the Whitehead Institute, including joint appointments of noteworthy quality.

Faculty and Staff

Professor Christopher T. Walsh was appointed Head of the Department of Chemistry and succeeds Professor James L. Kinsey, who will return to faculty rank in the Department. Professor Kinsey was an unusually effective and respected Department Head. In this post, he provided exceptional leadership and encouraged communication with industry. He also presided over two celebrations of the Department: the tenth anniversary of the dedication of the Camille and Edouard Dreyfus Building in 1980 and the 75th anniversary of the founding of the Research Laboratory of Physical Chemistry in 1978.

Professor Phillips W. Robbins, of the Department of Biology and the Center for Cancer Research, was elected to the National Academy of Sciences. Professor Herman Feshbach, Head of the Department of Physics and Cecil and Ida Green Professor of Physics, was elected President of the American Academy of Arts and Sciences.

Professor Mark S. Wrighton was awarded the F.G. Keyes Professorship of Chemistry. Professor Keiiti Aki was awarded the Robert R. Schrock Professorship of Geology and Geophysics. Professor Herman N. Eisen, Department of Biology, was appointed the first Whitehead Institute Professor. Professor H. Robert Horvitz, Department of Biology, was awarded the Whitehead Faculty Development Professorship.

Professors Richard C. Mulligan and Susumu Tonegawa joined MIT. Both professors hold joint appointments in the Department of Biology and the Center for Cancer Research. Dr. Gerald R. Fink, professor of genetics, also joined MIT with a joint appointment in the Department of Biology and the Whitehead Institute.

Professors George M. Whitesides and Edward I. Solomon resigned from the Department of Chemistry to accept positions at Harvard University and Stanford University, respectively. Professor Whitesides made unique contributions to MIT in both teaching and scholarship during his 19 years here. He will be difficult to replace, and his departure is a personal loss for the present Dean. Professors F. Read McFeely and William H. Rastetter also resigned from the Department of Chemistry. Professor Michael Bevan resigned from the Center for Cancer Research for health reasons and moved to the Scripps Clinic and Research Foundation in La Jolla, California. Professor John Lewis left the Department of Earth and Planetary Sciences to accept a position at the University of Arizona.

We were saddened by the deaths of Professor Sanborn Conner Brown, Department of Physics, on November 28, 1981, and Professor Charles E. Holt III, Department of Biology, on February 15, 1982. Professor Brown was a plasma physicist, an historian of science, a religious lay leader, and a professional and public servant. He served as associate dean of the MIT Graduate School from 1963 until his retirement in 1975. Professor Holt was a faculty member in the Department of Biology for 19 years. As a dedicated, innovative teacher, he contributed significantly to the undergraduate program. Professor Holt's research efforts, his professional activities, and his commitment to the quality of MIT life made him a highly regarded member of the Institute.

Professor Phillip A. Sharp was appointed associate director of the Center for Cancer Research.

JOHN M. DEUTCH

Department of Biology

In the past year, 257 undergraduate students were listed as majors in the Life Sciences and 91 received the degree of Bachelor of Science in Life Sciences. These consisted of 56 in the regular Course VII Program, 27 in the VII-A Program, and 8 in the VII-B Program. Most of these students will be attending graduate or medical school.

During the period from July 1, 1981, to June 30, 1982, 12 Ph.D.s were awarded in the Department, and 2 in the Joint Program in Biological Oceanography with the Woods Hole Oceanographic Institution. The maximum number of Ph.D. candidates registered in the Department in 1981-82 was 127, with another 25 in the Joint Program. The entering graduate student class in September 1981 was 23. The class arriving in September 1982 will contain 26 students.

Educational Activities

There have been no major changes in the undergraduate curriculum in the past year. The basic subjects taken by all students majoring in Life Sciences are 7.05 General Biochemistry, 7.03 Genetics, and 7.011 Introduction to Experimental Biology. These subjects are prerequisites for the other subjects in the Department listed as restricted electives in the undergraduate curriculum.

One of the important features of our undergraduate program is that every student should have the opportunity to participate in laboratory research. To accomplish this, several 24-unit project laboratories are available in which each student works on a specific research project under the supervision of a faculty member and/or other research personnel. This kind of experience in research is required of all of the students enrolled as regular Course VII majors. A student can satisfy this requirement by doing a project in the research laboratory of a faculty member and submitting a written report for evaluation by a faculty committee. This is to ensure that the completed work is equivalent to what we would expect of a student enrolled in a project laboratory.

During the past year two new 24-unit laboratory subjects in the biotechnology area have been organized and will be taught for the first time in the 1982-83 academic year. One of these subjects, to be taught in the fall semester, has been planned to introduce students to the use of bacteria and other microorganisms in "genetic engineering"; i.e., the transferring of genes from one organism to another. The second, to be taught during the spring semester, will concentrate on the use of animal cells in biotechnology.

The recipients of the annual John L. Asinari Awards for 1981-82 for outstanding research by undergraduates in Life Sciences were: Irmgard Behlau (supervisor, Professor Graham Walker); Eldredge B. Crenshaw (supervisor, Professor Richard Hynes); Joseph F. Sabik (supervisor, Professor Salvador Luria); and Lynn M. Schnapp (supervisor, Professor Vernon Ingram).

Research

The research activities of the Department are in the broad area of molecular biology which includes biochemistry, genetics, microbiology, cell and developmental biology, biophysics, virology, and immunology. Individual research projects are described in the annual departmental publication, *Biology Research Summaries*, available at departmental headquarters.

During 1981-82, the Whitehead Institute of Biomedical Research was established in close affiliation with MIT. The terms of the affiliation agreement allow for the joint appointment of scientists as members of the Whitehead Institute and faculty members of academic departments at MIT. Since it is expected that many of the appointees at the Whitehead Institute will have joint appointments as faculty members in the Department of Biology, the opportunity is thus available for the Department to strengthen already existing research and teaching interests and to develop new educational and research areas.

Personnel

Two new faculty appointments were made during the past year. Dr. Richard Mulligan was appointed as assistant professor on January 1, 1982, with a joint appointment and research space at the Center for Cancer Research. Dr. Mulligan received an S.B. in life sciences at MIT in 1976, and a Ph.D. from Stanford University in 1980. He was a postdoctoral fellow at MIT from 1980 until his appointment as a faculty member in 1982. Dr. Mulligan's research interests are in the area of the mechanism of gene expression in animal cells.

Professors F. Read McFeely, William H. Rastetter, Edward I. Solomon, and George M. Whitesides have resigned from the faculty.

Professor Mark S. Wrighton was named Frederick G. Keyes Professor of Chemistry.

Dr. John M. Deutch, Arthur C. Cope Professor of Chemistry, has been appointed Dean of the School of Science. He will succeed Professor Robert A. Alberty, who will return to research and teaching in the Department of Chemistry after 15 years of service as Dean of Science.

Professor Robert W. Field has been promoted to the rank of professor.

Activities of the Department

The Department was privileged to sponsor lecture series provided by the Arthur D. Little, T.Y. Shen, and Karl Pfister professorships. Professor William Wallace Cleland of University of Wisconsin delivered A.D. Little Lectures in biological chemistry on the topics "Effects of pH on Kinetic Parameters," "Isotope Effects I: Kinetic Mechanisms and Rate-Limiting Steps," and "Isotope Effects II: Chemical Mechanisms and Transition-State Structures." A.D. Little Lectures in Inorganic Chemistry were presented by Professor Stephen J. Lippard of Columbia University. His lectures were entitled "Chemical and Biological Studies of Cis-Diamminedichloroplatinum (II), an Anti-Tumor Drug," "Copper Chemistry in Binucleating Macrocycles and Protein Active Sites," and "Early Transition Metal Isocyanide Complexes: Stereochemistry and Reductive Coupling Reactions." Professor Ryoji Noyori of Nagoya University, Japan was Karl Pfister Visiting Professor. He lectured on "Toward Highly Enantioselective Reduction" and Tris(dialkylamino)sulfonium Enolates." Professor Jeremy R. Knowles, T.Y. Shen Visiting Professor in Medicinal Chemistry, presented lectures on "The Physical-Organic Chemistry of Phosphate Esters: Stereochemistry and Mechanism," and "The Enzymology of Phosphate Esters: Catalysis and the Nature of the Transition State." Professor George Pimentel of the University of California at Berkeley was the speaker for a special lecture honoring Dean Alberty's service as Dean of Science and celebrating the 50th Anniversary of the establishment of the School of Science. His topic was "Selective Excitation of the Fluorine-Allene Reaction in Cryogenic Matrices."

A new organization, the MIT Chemists' Club, was started with the help of the Alumni Association in order to foster closer relations between current and former members of the Department. The MIT Chemists' Club which is open to anyone who has been associated with the Department in any capacity, plans a variety of activities such as social gatherings at national meetings, career workshops for current students, research symposia, and a newsletter. Members of the organizing committee are: Professor Kinsey, Dr. Jennifer Logan (Ph.D. 1975), Dr. Thomas Gilbert (Ph.D. 1971), Dr. Charles Kolb (S.B. 1967), Dr. Arthur Obermeyer (Ph.D. 1956) and Dr. Arnett Powell (Visiting Scientist 1956 - present).

The program of the Chemical Sciences/Industry Forum, a group of industrial associates of the Department, included a two-day symposium on "Chemically Modified Surfaces: Synthesis, Characterization, and Applications" in June, arranged by Professors Sylvia Ceyer and Richard Schrock. Membership in the Chemical Sciences/Industry Forum has grown to 12 companies.

RESEARCH

Inorganic Chemistry

Professor Schrock and his group have been exploring the chemistry of organometallic complexes in which the metal is in its highest possible oxidation state. The focus of this work is on how these new organometallic molecules react with organic molecules, and, in particular, what types of reactions they catalyze. The organometallic compounds of greatest interest are those having metal-carbon double or triple bonds, particularly those in which the metal is molybdenum, tungsten, or rhenium. The overall goal of the research is to discover new catalytic reactions and new principles of catalysis. Some of the findings are also expected to prove relevant to known catalyst systems. Professor Schrock is also interested in ways of reducing carbon monoxide with molecular hydrogen (as a means of synthesizing fuels), in how molecular nitrogen is reduced

Dr. Gerald R. Fink was appointed as Professor of Genetics in the spring of 1982. Dr. Fink will hold the joint appointment as member of the Whitehead Institute of Biomedical Research. Dr. Fink received a B.S. in biology from Amherst College in 1962, after which he attended graduate school at Yale University where he received an M.S. in 1964 and a Ph.D. in 1965. After a two-year period as a postdoctoral trainee at the National Institutes of Health, Dr. Fink accepted a faculty position at Cornell University in 1967. He was promoted to associate professor in 1971 and to professor in 1976. Dr. Fink was awarded the National Academy of Sciences Prize in Molecular Biology in 1981, and was elected as a member of the National Academy of Sciences that same year. He also has held an American Cancer Society Professorship since 1981. Dr. Fink's research interests are currently in the general area of the molecular biology of yeast, with special emphasis on the regulation of gene expression.

During the year Dr. Frank Solomon and Dr. Walker were awarded tenure, Dr. Robert Sauer was promoted to associate professor, and Drs. Nancy Hopkins and Robert Weinberg were promoted to professor.

Dr. Michael Bevan left the Department to take a position at the Scripps Institute in La Jolla, California.

It is with regret and sadness that I report the untimely death of Professor Charles E. Holt III in the past year. Professor Holt received a B.A. in physics from Wesleyan University in 1957 and a Ph.D. in biology from MIT in 1962. He joined the Biology Department as a faculty member in 1963, and made important and lasting contributions in several research areas. He was a dedicated and innovative teacher who developed the concept of project laboratories in biology which have been so successful in the undergraduate educational program at MIT. His many activities made him a widely respected member of the MIT faculty. We shall all miss him very much.

Dr. Glenn M. Nagel from California State at Fullerton spent part of the year doing research work in Professor Paul Schimmel's laboratory, and Dr. Alan Schwartz from Harvard Medical School spent part of the year in Professor Harvey Lodish's laboratory.

I am pleased to report that Professor Phillips W. Robbins was elected to the National Academy of Sciences in the past year. Dr. Herman Eisen was named as Whitehead Institute Professor, Dr. Robert Horvitz was honored as the first recipient of the Whitehead Institute Career Development Chair, and Professor Phillip Sharp was appointed associate director of the Center for Cancer Research. Finally, it is a pleasure to report that in the past year Dr. Luria was coauthor of a new textbook in general biology, entitled *A View of Life*. This book was used as the text this past year in 7.01 General Biology at MIT, and also has been adopted as a text in many other leading colleges and universities throughout the country.

GENE M. BROWN

Department of Chemistry

Bachelor of Science degrees in chemistry this year were awarded to 38 undergraduates: 6 in February and 32 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 September, four in February, and two in June. A total of 36 Ph.D.s were awarded to 11 candidates in September, 7 in February, and 18 in June. To date, 1,667 Ph.D.s and 392 master's degrees have been awarded by the Deparment.

Personnel

Dr. Christopher T. Walsh, a biochemist and member of the MIT faculty since 1972, has been appointed Head of the Department of Chemistry, effective July 1. Professor Walsh will succeed Professor James L. Kinsey, who will return to research and teaching after serving the Department as Head since 1977.

to ammonia by molybdenum-containing enzymes, and in the systematic preparation of heterogeneous catalysts by attachment of homogeneous catalysts to inert organic supports such as silica.

Organic Chemistry

Research in Professor Rick Danheiser's laboratory centers on the development of new synthetic techniques, the invention of new reactions of broad applicability and significance, and application of these methods to the total synthesis of natural products and biologically important compounds. The reactions presently under investigation include stereo- and regioselective annulation approaches to cyclic organic compounds. All these new reactions were, in some sense, inspired by the Diels-Alder reaction, which is perhaps the single most powerful method for the synthesis of complex cyclic organic compounds. The goal of Professor Danheiser's work is to design reactions modeled on the Diels-Alder reaction, but which would apply to the synthesis of other ring systems.

The structures of many important natural products incorporate five-membered rings. Two powerful new annulation approaches to cyclopentane derivatives which have unique features of regioselectivity and stereoselectivity have been discovered recently by Professor Danheiser and his co-workers. The first involves a two-step [4+1] annulation to generate a cyclopentane derivative. In contrast to conventional high-temperature routes to these compounds, the new reaction proceeds at room temperature with remarkably high stereoselectivity. The second annulation approach is a one-step process with the unique feature that it can regiospecifically generate five-membered rings substituted at each position and functionally equipped for further synthetic elaboration. This reaction is also highly stereoselective and promises to be extremely valuable in the synthesis of compounds containing five-membered rings.

At present there exist very few general methods for the synthesis of eight-membered carbocyclic compounds, despite the presence of such rings in large numbers of interesting natural products. Professor Danheiser and his group have developed a new [4+4] annulation approach to cyclo-octane derivatives which involves the thermal combination of a 1,3-diene and a cyclobutenone derivative. They are examining its application in the total synthesis of the antitumor agent taxol. In related work, they are completing the final stages of a short and practical total synthesis of the potent neurotoxic alkaloid anatoxin a, whose structure also incorporates an eight-membered ring. This synthesis will make this anatoxin a and analogs available in quantity, and will facilitate its application in neurophysiological research.

Physical Chemistry

Professor Robert Silbey's research group has been working to understand the properties of the newly discovered doped conducting polymers. Polymers such as polyacetylene, polyparaphenylene and polyphenylene sulfide can be doped with electron acceptors such as AsF_5 and I_2 to yield systems which conduct at levels approaching doped silicon ($\sim 10^3$ ohm^{-1} cm). This is an unusual and interesting phenomenon because organic molecules do not, in general, conduct electricity well. It is thought that the conjugated structure of the polymers is a necessary ingredient for the high conductivity. However, the basic mechanism of the process is not yet understood.

Professor Silbey and his co-workers have been using the techniques of quantum chemistry to model these molecules in their undoped and doped states. They found, by studying the energetics of the radical-ion pair formed on doping in polyacetylene, that this pair tends to remain tightly bound until high doping levels. At this point, the pairs break into "solitons." In polyparaphenylene, by contrast, the pairs never break apart; however, doubly charged pairs can occur (bipolarons) giving rise to spinless conductivity. These theoretical observations, along with other predictions, fit the experimental data qualitatively. More extended calculations and new experiments need to be done to find out whether the model is correct.

In addition, by studying the electronic states of the undoped polymers using quantum mechanical methods, Professor Silbey has been able to predict which polymers can be doped by various electron acceptors and what the resultant conductivities will be. These predictions have proved very useful to the experimentalists who prepare the undoped polymers, by allowing them to focus on those which will be dopable and will yield high conductivities.

Among the projects in Professor Kinsey's laboratory is a study of the Photoemission spectrum of ozone excited with laser light at visible or ultraviolet wavelengths. It is well known that absorption of photons of these energies causes extremely rapid ($\sim 10^{-14}$sec) photodissociation of ozone, resulting in quite low fluorescent yields ($\sim 10^{-6}$). Nevertheless, with excitation at 266nm wavelength, Professor Kinsey and co-workers have observed enough photoemission to record well-resolved fluorescence spectra. These spectra exhibit vibrational structure in the ground electronic state from the bottom of the potential well clear up to the dissociation limit at about 1 eV. This is the first example in which such a complete manifold of vibrational levels has been observed for a polyatomic molecule.

The high-resolution structure of the higher vibrational levels, which is now under investigation, is expected to reveal details of dynamics on the ground-state potential surface. In particular, it is anticipated to shed light on the onset of chaotic motion in the molecule as its internal excitation is increased. Besides the ground-state properties inferred from the line positions in the photoemission spectrum, the intensity pattern can be used to monitor short-time dynamic processes on the excited electronic state's potential surface. At this time, the relative intensities of the first few fluorescent lines displaced from the exciting line have been used to determine the local geometry of the upper surface in the neighborhood of the ground state equilibrium configuration.

The ability demonstrated in these studies for observing photoemission from diffuse band systems has revealed hitherto unexploited possibilities for spectroscopic probing of dynamics on repulsive as well as bound surfaces for polyatomic molecules.

Biological Chemistry

Professor Mary Roberts' research is concerned with two major topics: 1) micellar lipid-protein systems as models for lipolysis and lipid transport, and 2) responses of intact cells to chemical and physical modifications of their membranes. A variety of physical techniques (primarily NMR with excursions into Raman and QELS) are used to investigate these areas.

Lipid adsorption, transport, and hydrolysis are important biological phenomena where the aggregate nature of the substrate makes detailed mechanistic studies difficult. Lipolytic enzymes such as phospholipase, while capable of hydrolyzing non-aggregated (monomeric) lipids, require an interface or aggregated substrate for optimal activity. Synthetic short-chain lecithins and analogs form a kinetically and spectroscopically ideal system to study this interfacial activation. Long-chain phospholipids spontaneously form bilayers when dispersed in water. These short-chain species, in contrast, exist as monomers below a critical micelle concentration, and as micellar aggregates of a size dependent on fatty acyl chain length above that concentration. Kinetic and spectroscopic studies of recombinants with short-chain lecithins have been used to understand the mechanism of these surface-active enzymes. The physical studies of the short-chain lecithins can be exploited further in the development of a synthetic model for serum lipoproteins, which are aggregates responsible for fat storage and transport in mammals.

The response, both immediate and adaptive, of intact cell membranes to various stresses is critical to cell survival. Professor Roberts' group has focused on an anaerobic thermophilic bacterium, *Clostridium thermocellum* (used for conversion of biomass to ethanol and other fuels), and polymorphonuclear leukocytes (phagocytotic mammalian cells). ^{31}P- and ^{13}C-NMR studies of intact cells were used to probe the effects of exogenous materials which partition into membranes/hydrophobic sites (n-alkanols, fatty acids, etc.), chemical modification (phospholipase digestion, cholesterol oxidase, etc.) and physical modification (heat, pressure) of membrane components on cell metabolism. Specifically, the generation of proton and chemical gradients across the membrane, membrane permeability to amino acids, phosphate, and glycolysis (ATP production) are studied. Of particular interest are the transient tolerance responses of cells to some of these perturbations.

JAMES L. KINSEY

Department of Earth and Planetary Sciences

FACULTY

On July 1, 1981, William F. Brace, Cecil and Ida Green Professor of Geology, succeeded Carl Wunsch as Head of the Department. Professor Wunsch has been on leave in England during the past year. Keiiti Aki became Robert R. Shrock Professor of Geology and Geophysics, and Professor John Sclater became MIT director of the Joint Program in Oceanography and Oceanographic Engineering with the Woods Hole Oceanographic Institution. Nafi Toksoz was appointed director of the Earth Resources Laboratory. As of July 1, 1982, Dr. Barry Parsons will become Associate Professor of Geophysics, and Marcia McNutt will become Assistant Professor of Marine Geophysics. John Lewis resigned from MIT on September 30, 1982, to become a professor at the Univeristy of Arizona. On July 1, 1982, Charles Counselman was promoted to full professor, and Edward Boyle to associate professor without tenure. Dr. Michael Solomon was Crosby Visiting Lecturer during the spring term.

Honors

Professor Sclater became a Fellow of the Royal Society. Professors Wunsch, Irwin Shapiro, and Sean Solomon received Guggenheim Fellowships, and John Edmond will be Fairchild Professor at the California Institute of Technology this winter.

ENROLLMENT

Graduate enrollment remained nearly constant, with 80 students at MIT and 40 enrolled in the Joint Program at Woods Hole. Applications for graduate school were up about 30 percent, and the quality of applicants is excellent. Undergraduate enrollment was 43. We have begun a vigorous recruiting program to increase this number.

RESEARCH

The members of the Department conduct research over a broad spectrum of earth and planetary science. 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. A few highlights are given here.

Geology and Geochemistry

Professor Clark Burchfiel and his students are currently studying the large-scale compressional and extensional tectonics of northern Norway and the western United States. In Scandinavia, the deep erosional level, equivalent to midcrustal depth, reveals subduction of several hundred kilometers of continental crust, followed by imbrication of the downgoing plate itself. If this result is generally true, the deeper levels of many orogenic belts will need to be reinterpreted. In the Cordillera, they have found extensional structures closely akin to thin-skinned thrusting, although the structures are not influenced by the position of older thrust faults.

Professor John Southard extended his work on dynamics of bed forms under unidirectional water currents. He completed experiments using large sand waves as a function of sand size and current velocity in a large recirculating flume at scales larger than in any previous experiments.

There is a spectacular increase in bed-form size with increasing flow velocity, and the largest sand waves have large forms superimposed upon them at equilibrium.

One of Professor Fred Frey's major efforts continues to be on volcanic products formed along the linear Emperor-Hawaiian ridges in the Pacific. Study of the Loihi seamount shows that the source composition of Hawaiian magmas varied with time, and that the source of Hawaiian tholeiites, the most voluminous basalt type, is derived from a deeper and compositionally more primitive source than basalts formed along axes of plate divergence.

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.

Professor Stanley Hart and Principal Research Scientist Nobumichi Shimizu, using the MIT-Harvard-Brown consortium ion microprobe facility, have developed a precise technique for analyzing lead (Pb) isotopic abundances in ore minerals such as galena. Lead isotope ratios can be determined on areas as small as 10μm, thus allowing them to "contour" single galena crystals in terms of lead isotopes. Individual galena crystals can thus be used as "recorders" of the temporal evolution of ore-forming solutions. They are applying this technique to the largest Pb producing district in the US, in an attempt to determine the sources of the Pb, the spatial flow patterns of the ore fluids, and the temporal relationships of ore deposition between the various mines.

Professor Timothy Grove has proposed a coherent phase diagram for the plagioclase feldspar system. This treatment has linked the order-disorder phase transitions and the observed phase separations in a complicated mineral system by proposing the existence of three tricritical points. Our results should stimulate new approaches to understanding metastable behavior in rock-forming mineral systems.

Professor Frank Spear and colleagues have been studying the petrologic and tectonic evolution of Penninic rocks of the central and western Tauern Window, Austria. They found that siliceous dolomites in the central Tauern Window crystallized at 20kb. This is the highest pressure ever calculated for any metacarbonate rocks, and it implies extreme crustal thickening in this portion of the Alps during the early collisional event.

Professor Roger Burns and his group have conducted a variety of geochemical studies involving transition metals in minerals, ranging from the iron oxide mineralogy of Mars to the evolution of sulfide ores in submarine chimneys along the East Pacific Rise. Using diffuse reflectance spectroscopy measurements of well-characterized natural and synthetic phases, they deduced that feroxyhyte and ferrihydrite are abundant constituents of the regolith at the two Viking landing sites on Mars. Using scanning electron microscopy and electron microprobe techniques, they demonstrated that the deposition of sulfide minerals of zinc, copper, and iron at oceanic spreading centers is controlled by the temperature of hydrothermal fluids emanating from vents on the seafloor.

Geophysics

Professor Solomon and colleagues have been working on the characteristics of earthquakes on mid-ocean ridges and transforms as a means to investigate the thermal and mechanical behavior of young oceanic lithospheres. Large earthquakes are studied teleseismically by modeling the waveforms of P waves and by inverting the surface waves for source moment tensor and focal depth. Interesting results to date include the demonstration that, from the depth extent of faulting during large ridge crest earthquakes, hydrothermal circulation must have cooled the entire oceanic crustal column. The repeat time of the largest earthquakes on slowly spreading ridges also matches the geological observed interval between major eruptive episodes along a given segment of ridge.

Professor Theodore Madden has been investigating motions in the upper part of the earth's core as revealed by secular variations of the earth's magnetic field, and is trying to understand the significance of a core-wide jump in the motion accelerations that is inferred. These motions have significance for the generation of the magnetic field and perhaps even for the heat-flow balance of the mantle.

Professor Toksoz has established the Earth Resources Laboratory to expand the teaching and research activities of the Department into energy and mineral resources areas. Two important topics are under investigation: the use of full waveform acoustic logs in the borehole investigation of formation properties, and the development of vertical seismic profiling as a tool for definition of major fractures in the subsurface.

Professor Aki and colleagues have operated a network of nine digital even-recorders (constructed at MIT) around the body of Mt. St. Helens, including one inside the crater. Excellent records of seismic events have been collected, including so-called "long-period events," which are quite similar to those observed at Kilauea, Hawaii and associated with vibrations of the magma reservoir.

Professor Brace and Senior Research Scientist Joseph Walsh have been studying the flow of fluids in crystalline rocks. A major discovery was that permeability at scales greater than 10 meters is not much different from that of porous sandstone, to depths of 5 to 10 kilometers. Flow in crystalline rocks occurs principally through a pervasive network of highly conductive fractures.

One of the primary interests of Professor Peter Molnar's group is the investigation of tectonic environments through the field observation of earthquake activity. Processing of the data collected in Afghanistan from 1976-78 has now been completed. An interesting result was the discovery of a significant low velocity region beneath the Hindu Kush region of Afghanistan, which strongly suggests the subduction of substantial amounts of continental crust. This will be contrasted with the style of Andean-type mountain building, based on two years of observations in Peru.

Professor Gene Simmons and colleagues have shown that granites from Redstone Quarry (NH), Granite Hills (WY), and Sherman Mountain area (WY) contain healed microcracks, that rare earth elements are mobile and have migrated in the geologic past, and that microcracks have provided the pathways for the migration of uranium. Similar studies of microcracks have potential for predicting the extent of migration over geologic time of radioactive isotopes from waste repositories in crystalline rocks.

Oceanography

Professor Boyle has initiated a study of the three-dimensional time-dependent variability of deep-ocean circulation using benthic fossil trace element chemistry. Initial results indicate that Glacial North Atlantic Deep Water diminished by a factor of two (relative to the present day in the depth range 2,500 to 3,500 m) but was relatively unchanged above 2,200 m.

Professor Edmond completed two major ALVIN diving cruises to the submarine hot springs in the Eastern Pacific. On the East Pacific Rise, south of Baja California, samples of water issuing from the sea floor at 350° C. were collected. Chemical analysis showed that the waters are ore-forming solutions of the type responsible for the massive sulphide deposits found in western Canada. On the second cruise, near the central part of the Gulf of California, water as hot as 315° C. contained oil as an immiscible phase! These hydrocarbons result from the cracking of planktonic carbon occluded in the sediments by the hot waters.

Using a new upper ocean-moored current and density profiler, Professor Charles Eriksen continued his program of accurate, detailed, long-term measurements of the evolution of upper-ocean structure in response to wind and thermal forcing. Recent work in the Gulf Stream indicates that upper-ocean internal waves and mixing processes are strongly influenced by a Gulf Stream Ring. Rings are thus crucial elements in determining the type and rates of water mass formation, which, in turn, have implications for climate.

Professor Sclater and his colleagues at MIT and Woods Hole have been working on the heat flow, subsidence, and thermal maturation histories of continental shelves and sedimentary basins. They recently have completed a multi-year study of the Pannonian Basin, Hungary. This region was shown to contain several small pull-part basins, some of which are in close proximity to the foreland thrust belt which frames the Pannonian Basin. During the year he participated in these cruises and collected new heat flow and geophysical data in the Mediterranean Sea and along the Blake-Bahama Rise.

Professor Wunsch and his collaborators at MIT and several other institutions have demonstrated, with an at-sea experiment, that ocean acoustic tomography is a powerful new observational tool for measuring and mapping the ocean on very large scales for long periods of time. The technique is analogous to the medical procedure called "CAT" and to some aspects of seismology. It opens the possibility, for the first time, of observing the ocean on the large scales required to understand its behavior and its role in climate.

Planetary Science

Professor Shapiro and colleagues have found radio observations of the double quasar 0957+561A,B which appear to confirm that light from a single quasar is split into multiple images by the gravitational fields of foreground galaxies. Preliminary analysis from a major six-station very-long baseline interferometry observation, utilizing the Mark III data acquisition system, has resulted in the detection of a third source that may be either the core of the bender galaxy or another image of the quasar.

Professor Counselman's group has developed a portable instrument that uses microwave radio signals from earth satellites to measure relative position vectors between points on the ground. With this instrument, no line of sight between the points is needed. Accuracy of one part per million has been demonstrated in measurements of a 36-kilometer distance, both in fair weather and during heavy rain. Scientific applications of the instrument include the monitoring of strain near faults in the earth's crust for use in earthquake-predictive research. When combined with conventional geodetic leveling measurement, data from the new instrument can also yield high-resolution maps of regional variations in the earth's gravity field.

Professor Gordon Pettengill completed the analysis of Venus orbiter data to obtain a map of that planet's radar reflectivity. Several regions were found with relatively high reflection efficiencies, which probably result from the presence of substantial amounts of near-surface iron pyrites. In ground-based radar observations, the nucleus of the comet Grigg-Skjellerup was seen for the first time, providing unambiguous evidence that a small nucleus exists.

An extensive search for rings around Neptune, conducted from several observatories by Professor James Elliot and his colleagues, revealed no rings to a limit of 0.07 in optical depth. Hence, any ring system of Neptune must be less extensive than the ring systems of Uranus and Saturn, but a tenuous, Jovian-type ring would have escaped detection by their search. The apparent lack of rings around Neptune is puzzling, since it would be the only gas-giant planet without them.

WILLIAM F. BRACE

Department of Mathematics

During the 1981-82 year there were 178 undergraduates and 120 graduates majoring in Mathematics. The Bachelor of Science was awarded to 58 students. There were 10 recipients of the Master of Science and 13 recipients of the Doctor of Philosophy in Mathematics.

Undergraduate Program

Professor Frank Morgan, after three years as chairman of the Undergraduate Committee, will be succeeded July 1, 1982 by Professor Arthur Mattuck, holder of the Class of 1922 Professorship.

This spring, the first business meeting of Department faculty in many years discussed the curriculum for majors and the format of calculus.

The Department has had some success in bringing greater depth to freshman calculus. Professor Morgan launched a new, year-long calculus sequence, 18.011-18.021, to replace the shorter 18.01C-18.02C. This new sequence now includes applications and topics in probability,

celestial mechanics, and complex numbers in addition to the standard curriculum. The old sequence tended to exacerbate concerns about pace and overloading in the freshman year. This year's drop of 200 freshman registrations in 18.03 Differential Equations suggests the beneficial effects of the new sequence.

Professor Hartley Rogers extensively deepened fall 18.02 Multivariable Calculus for freshmen with advanced placement credit. For example, the unit on vector integral calculus went beyond Stokes' Theorem to discuss the vector potential of a divergence-free field, the Bohnn-Aharonov Effect, and Helmholtz's Theorem.

Furthermore, all of the large calculus subjects have introduced problem sets and final examinations. Student test performance seems to have improved substantially.

Mathematics majors and prospective majors today are concerned about career possibilities. The Department is studying a proposal for an internship program to give more majors the opportunity for rewarding work in business and industry before graduation.

Faculty

Associate Professor David Vogan was awarded tenure, further strengthening our Department as the leading center for the study of Lie theory and group representation. Andrew Fowler was promoted to Assistant Professor of Applied Mathematics.

Professor Franklin Peterson, after six years as chairman of the Pure Mathematics Committee, will be succeeded by Professor Michael Artin. This Committee makes recommendations for appointments and promotions for the Pure Mathematics section of the Department. Professor Nesmith Ankeny will succeed Professor Stephen Kleiman as chairman of the Graduate Committee.

The following individuals were C.L.E. Moore Instructors during the past year: Dr. Jeffrey Adams, Dr. Kaan Akin, Dr. Dean L. Alvis, Dr. Barry Cipra, Dr. Nils J. Dencker, Dr. William Goldman, Dr. Marcia Groszek, Dr. Philip Hanlon, Dr. Stephen Mitchell, Dr. David Pengelley, Dr. Wade C. Ramey, Dr. Susan Szcepanski, Dr. Ross Urwin, and Dr. Rodney Ian Yager. The following were Instructors of Applied Mathematics: Dr. John Buoncristiani, Dr. Elaine Chandler, Dr. Steven Ellis, Dr. Fowler, Dr. Arthur Rosenthal, and Dr. Marius Ungarish.

Faculty members on leave during the past year were Professors Leonard Adleman, Louis Howard, Daniel Quillen, and Gerald Sacks. On leave during the spring were Professors Daniel Kan, George Lusztig, and Harold Stark.

The Statistics Group, headed by Professor Herman Chernoff, moved into newly renovated quarters in Building E40.

Research note: A 25-year-old conjecture in topology has been solved. The immersion conjecture states that every differentiable manifold of dimension n can be immersed in Euclidean space of dimension $2n - \alpha(n)$, where $\alpha(n)$ is the number of ones in the dyadic expansion of n. This conjecture had been made in the late 1950s, but only in the last seven years has a solution seemed possible. The solution is a result of the work of Professor Peterson of our Department, Professor E.H. Brown, Jr., of Brandeis, and Professor R.L. Cohen of Stanford.

Professor Ankeny wrote a satirical article in the *New York Times* on presidential motives in international politics analyzed via game theory. Beginning with the analogy that "Playing President is like playing poker" (*NYT* 2/14/82), Professor Ankeny surmised that the President is trying to call a bluff, albeit with the wrong hands, and that if he is caught, "It's no longer a question of whether he'll come out a loser, but how much he'll lose," and who will pay for his losses.

The following held visiting appointments during the past year: Professor Curtis Greene (Haverford), Professor Julius Shaneson (Rutgers), Dr. Peter Breitenlohner (Germany), Dr. Marc Brachet (France), Dr. Gen Nakamura (Japan), and Dr. Gabrielle Stoy (England).

Honors

Professor Chia-Chiao Lin delivered two James R. Killian, Jr., Faculty Achievement Award lectures on Density Wave Theory of Spiral Galaxies. The lectures were entitled "Galaxies: Morphology, Luminosity and Dynamics" and "Milky Way: Mechanisms and Mathematics."

Professor Gian-Carlo Rota was elected to membership in the National Academy of Sciences.

Professor Morgan received the Everett Moore Baker Award for excellence in undergraduate teaching.

Professor George Lusztig was awarded a Guggenheim Fellowship.

Joshua Bernoff, a third-year graduate student in logic, received MIT's William L. Stewart, Jr., Award for his work in the Experimental Study Group.

One of our seniors, Andrew J. Bernoff (Josh's brother), has been awarded a British Government Marshall Scholarship. He will study applied mathematics and fluid mechanics at Cambridge University.

DANIEL J. KLEITMAN

Department of Meteorology and Physical Oceanography

On July 1, 1981, Professor Peter H. Stone assumed the position of Head of the Department. Professor Edward N. Lorenz, who had been Department Head since 1977, stepped down and departed for a well-deserved sabbatical.

Kerry Emanuel, a 1978 graduate of our Department, joined us as Assistant Professor of Meteorology. Professor Emanuel, who had been on the faculty at UCLA, specializes in mesoscale dynamics and cumulus convection. Another of our graduates, Neil Gordon, took a leave of absence from the New Zealand Meteorological Service to spend a year in our Department as visiting scientist. Dr. Gordon, who received his Sc.D. from us in 1978, is working primarily with our Doppler radar group conducting research in mesoscale systems. Another visiting scientist for the year is Dr. Mai Tsun Li. Dr. Li is an associate professor and head of the Section of Statistical and Dynamic Weather Forecasting at the Institute of Atmospheric Physics in Beijing, China.

This past year we made the first two awards for graduate study in our Department, which will be financed by two endowment funds established by friends and alumni of the Department. With the concurrence of the donor, the awards to be made from one of the funds have been named the Jule G. Charney Awards, in honor of the late Professor Charney.

Ronald G. Prinn, a theoretical atmospheric scientist who has made notable contributions in the field of atmospheric chemistry, was promoted to the rank of professor. Professor , Emeritus, Henry G. Houghton, received the 1982 Cleveland Abbe Award of the American Meteorological Society for distinguished service to the atmospheric sciences by an individual. He was chosen "for his long and dedicated service to the meteorological profession as beloved university teacher, administrator, and student advisor; as Councilor, Secretary, and President of the American Meteorological Society; and as a founder of the University Corporation for Atmospheric Research." Professor Lorenz was elected a foreign associate of the National Academy of Lisbon, Portugal.

Research

Professor Mark Cane has developed an analytic theory to account for the effects of low-latitude islands on the long low-frequency waves that are important in the adjustment of the equatorial

ocean to changing winds. The theory shows that none of the existing islands will significantly alter the adjustment process. The theory has been extended to treat the influence of irregular coastal geometries such as the Gulf of Guinea and the South American shoreline in the vicinity of the Amazon.

Professor Cane also has developed a theory that explains the transient behavior of equatorial currents. The theory was originally developed to explain observations in the Indian Ocean but has since been applied successfully to observations in the Atlantic and Pacific. In particular it accounts for the transport maximum in the (northern) spring when the winds are weakest, and for the predominance of eastward surface flow at the equator.

Professor Emanuel's research efforts have focused on the refinement and observational verification of the symmetric baroclinic wave-CISK theory of two-dimensional moist convection. The theory attempts to account for the development and character of pre-frontal squall lines in middle latitudes, and makes specific predictions which are testable using observations of actual squall lines.

He also has conducted research on the propagation of internal gravity waves in slowly varying flows which contain mean vertical motion. It has been possible to show that large-scale subsidence is effective in trapping mesoscale internal waves near the surface, and that large-scale divergence prevents the absorption of internal waves by critical layers. These results may have significant implications for the amounts of internal wave energy detectable near the surface.

Professor John V. Evans and his associates at the Millstone Hill radar are conducting a program of radar investigations of the structure and dynamics of the middle and upper atmosphere. Drs. P.K. Rastogi and G.B. Lomot are exploring motions in the upper troposphere-lower stratosphere by observing the Doppler-shifted returns from clear-air turbulence advected by the wind. During July 1981, they carried out a joint campaign with the Air Force Geophysics Laboratory to study the morphology of turbulence by optical, radar, and *in-situ* methods. More recently they have carried out observations at low-elevation angles, employing fine Doppler resolution which reveals the existence of braided structures and bursts of turbulence in which the layer thickness rapidly increases by several hundred meters.

Professor Glenn Flierl is leading the theoretical efforts for the National Science Foundation (NSF)-sponsored Warm Core Rings project, as a member of the executive committee for the project. During 1981 and 1982 there will be five cruises, each with three or four ships, to observe the physical, chemical, and biological characteristics of these warm eddies cut off to the north of the Gulf Stream. Modeling efforts have begun to suggest approaches for understanding the evolution of the physical variables. Professor Flierl's work has shown that warm core rings will not only propagate due to Rossby wave motion processes acting on the strong circulations in the near-surface layers, but will also radiate energy in the form of Rossby waves in the deep ocean. These waves will not only cause a spin-down of the eddy, but will also exert forces on the pool of warm water which can force a southward motion.

Biological modeling is also an important element of the program. Professor Flierl has examined one problem which is important to fisheries: the impact of rings upon larval fish populations in the shelf water. This research has demonstrated that there is a critical range of ring motion speeds relative to the mean flow in which the ring sweeps a large proportion of the larvae off the shelf and significantly reduces the population stock.

Professor Don E. Harrison has mapped and studied the upper ocean temperature field in the western North Atlantic, as sampled during the POLYMODE experiment, and has compared the results with pre-existing data and theoretical ideas. He has found that the idea that the mid-ocean variability can be represented well by the barotropic and first baroclinic mode does not work well for this data set. He has also almost completed a one-degree-by-one-degree data set of all the climate data in the US archives. As a member of the SEQUAL scientific council, he has continued to work on the design and planning of the SEQUAL field program to measure the seasonal cycle of the equatorial Atlantic Ocean.

Professor Lorenz, while spending part of his sabbatical at the European Centre for Medium Range Weather Forecasts, has used the Centre's standard forecasts to determine both lower and upper bounds on the predictability of instantaneous weather patterns in winter. He concludes that improvements in the numerical forecast models and observing systems have the potential for producing better-than-guesswork forecasts nearly two weeks in advance.

Professor Erik Mollo-Christensen has found that the nonlinear modulation pattern of surface waves can be strongly excited by current shears of the right magnitude, and that this can explain the apparent sensitivity of sea surface waves to inhomogeneities. Professor Mollo-Christensen, in collaboration with Dr. Ramamonjiarisoa of the University of Aix-Marseille II, has also found that wave modulations are coupled to modulations in the wind profile, so that these two phenomena need to be treated jointly. In a joint undertaking with S. Worthem and F. Ostapoff of NOAA/AMOLS/SAIL, Professor Mollo-Christensen has found that traveling wave thermohaline instabilities are possible in the tropical ocean, and their results imply that salt and heat gradients in the ocean should follow a log-normal distribution under certain conditions.

Professor Reginald E. Newell and his collaborators completed studies of paleoclimatic reconstructions of air and sea temperatures around Africa for the past 18,000 years. They believe these reconstructions may best be interpreted in terms of the higher wind velocities at that time. In their studies of the mechanisms of present-day climate, the group has used carbon monoxide measurements made with a radiometer mounted on an aircraft to trace air masses. They found a significant penetration of southern hemisphere air into the Northern Hemisphere in the Arabian Sea region during the 1979 monsoon. Professor Newell is a member of the NASA science team that organized an experiment on the November 1981 flight of the Space Shuttle to measure carbon monoxide throughout the tropics. During the flight, data was acquired over a total flight path of one million kilometers, and it is now being used to study the processes of interhemispheric exchange and the sources and sinks of carbon monoxide. Professor Newell has also obtained evidence from aircraft measurements of cosmic-ray-induced Be^7 that exchange of air from the troposphere to the stratosphere occurs most rapidly during the November to February period.

The Weather Radar Laboratory, under the direction of Professor Richard E. Passarelli, demonstrated its new Doppler radar signal processor during an intensive field experiment in December 1981. The experiment also involved the NOAA P-3 research aircraft, and focused on the New England coastal front and pre-warm frontal precipitation bands. Co-investigators on this project included Professors Sanders and Emanuel and Mr. Spiros Geotis. An unexpected finding was that the hills and small mountains in southern New England play an important role in determining the distribution of pre-warm frontal precipitation. A spinoff design of MIT's new Doppler radar processor, manufactured by Enterprise Electronics Corp., represents the first large-scale commercial application of Doppler weather radar technology. Perhaps the single most important application of Doppler radar technology is the detection of tornadic thunderstorms and the provision of early tornado warnings.

Professor Passarelli and his students are also studying the microphysics of snow growth. They used a unique airborne sampling technique to verify the theoretical predictions of Professor Passarelli's analytical model of snow growth, and discovered that ice particle breakup is an important process for generating secondary ice particles and shaping the size-distribution of snow. This finding has implications for cloud seeding and the remote sensing of snow via radar.

Professor Raymond Pierrehumbert is currently engaged in a program of research aimed at elucidating a number of aspects of the influence of topography on atmospheric motions. He has completed a two-dimensional numerical mesoscale model, and a general code for determining the three-dimensional stability of two-dimensional flows involving topography. The theoretical research is coordinated with the ALPEX field program, a Global Atmospheric Research Program experiment designed to provide data on cyclogenesis and other mountain-induced phenomena in the neighborhood of the European Alps. The data set collected during March and April of 1982 has unprecedented resolution, and for the first time will make it possible to test a number of extant theories of lee cyclogenesis.

Professor Prinn has been working on the analysis of the first three years of data obtained in the Fluorocarbon Atmospheric Lifetime Experiment. This data comes from five automated ground stations in Ireland, Oregon, Barbados, Samoa, and Tasmania, which make measurements of $CFCl_3$, CF_2Cl_2, CH_3CCl_3, CCl_4 and N_2O roughly every six hours. All five of these species decompose in the stratosphere, leading to ozone destruction. A series of eight papers have been submitted to the *Journal of Geophysical Research* describing the experiment, the data, and its analysis using an optimal estimation technique to determine the atmospheric lifetimes and global budgets of each species.

Professor Prinn also has completed and published work on the chemical cycles in the Venus atmosphere, on the origin and evolution of planetary atmospheres, and on the chemical effects

of the collision of an asteroid or comet with the earth and its implications for the Cretaceous-Tertiary extinction. In collaboration with Professor John Lewis, he has written a book entitled "Origin and Evolution of Planetary Atmospheres," which will by published by Academic Press.

Professor Paola Malanotte Rizzoli has been carrying out theoretical research on the mechanisms for producing coherent, long-lived dynamical structures in the oceans and atmosphere. She has been focusing on the possible role of boundary forcing in producing "rings" in the Gulf Stream, and the possible role of topographic forcing in producing blocking ridges in the atmosphere. In addition, she has undertaken a new research project as a member of the Tomography Group, which is using acoustic techniques to explore the ocean interior. Acoustic rays are transmitted and recorded by source/receiver pairs, and the interior density field of the oceans can be reconstructed from the measured travel time of the acoustic rays. Professor Rizzoli will use the tomographic data, in conjunction with dynamical models of the ocean's general circulation, to improve estimates of the dynamical balances and turbulent fluxes in various oceanic regions.

Professor Frederick Sanders has made an intensive study of the conditions leading to the onset of severe thunderstorms in the Great Plains. He used the severe storms which occurred on April 10, 1979, for a case study. On this date, numerous special soundings and other observations were made by Project SESAME. He found that the air-mass instability responsible for the storms was due 40 percent to horizontal transport of warm air at low levels beneath unusually cold air aloft; 40 percent to intense heating of the lower troposphere during the morning over the arid regions of west Texas; and 20 percent to adiabatic cooling produced by a short-wave trough propagating eastward from New Mexico.

Professor Stone and his collaborators have applied NASA's Goddard Institute for Space Studies' three-dimensional climate model to a study of the mechanisms which force the zonal (east-west) circulations in the tropical atmosphere. They found that the primary drive for these circulations is not the commonly quoted zonal gradients in ocean surface temperatures, but rather the zonal contrasts in surface heating between the oceans and the continents. However, they did find that the zonal circulations in the tropical Pacific are particularly sensitive to forcing by ocean surface temperature gradients, and that both drives are needed to explain the zonal circulations in this area.

PETER H. STONE

Department of Nutrition and Food Science

EDUCATIONAL ACTIVITIES

Graduate Degree Programs

Graduate degrees (S.M., Ph.D., or Sc.D.) are currently awarded in five areas of specialization: nutritional biochemistry and metabolism, neural and endocrine regulation, food science and technology, biochemical engineering, and toxicology. Over the past year, in the process of redefining departmental goals, each of these graduate programs has been critically examined and revised. Particular emphasis has been placed on the nutrition and food science/biochemical engineering programs.

Significant developments have taken place with respect to the food science/biochemical engineering area, in that substantial progress has been made in formulating the framework of a new graduate program in Biotechnology, which represents coalescence of certain elements of the two existing degree areas. The new program will involve three disciplinary areas: microbiology/genetics, biochemistry/chemistry, and chemical engineering/biochemical engineering. The objective will be to prepare students for careers that apply modern biology, biochemistry, and engineering to problems in the production of chemicals, foods, and medicinal agents. Core courses are being developed that will deal with biological transformation, bioreactor design, and product isolation and recovery. It is anticipated that the first of these will be offered in the 1982-83 academic

year, with the others to follow subsequently. These core courses will be supplemented by additional subjects appropriate to the backgrounds and research projects of students in the program.

With a growing awareness by the health professions that the application of nutritional principles is essential for prevention, diagnosis, and treatment of human diseases and in the formation of lifestyles that promote optimal health within complex environments, the Department has continued to develop and offer scholarly, advanced training for students concerned with careers in nutrition. The teaching and research programs in nutrition are based on the principles of biochemistry and physiology, with particular reference to metabolic regulation. The common thread throughout the program is the study of relationships between dietary factors and mammalian metabolism. Such studies require an understanding of all levels of metabolic organization, ranging from subcellular to whole body, including extensive use of human and non-human experimental models. In order to meet these objectives, students in the curriculum acquire competence in the fundamentals of biochemistry, physiology, intermediary and protein metabolism and its regulation, and in basic and human nutrition. Opportunities are then provided for specialization as resources and faculty expertise permit.

In the 1981-82 academic year, a total of 152 graduate students were enrolled as degree candidates in S.M. or Ph.D. programs. Doctoral degrees were awarded to 25 students, and S.M. degrees to 21.

Undergraduate Programs

Enrollment in the undergraduate curriculum in Applied Biology (Course VII-B) in the 1981-82 academic year was 37 students. Faculty and staff also participate in other undergraduate activities, as freshman advisors (10), UROP project supervisors (92), and advisors for premedical students (30).

Students majoring in VII-B tend to fall into two groups -- premedical students, and those with career interests in some aspect of applied biology (i.e., toxicology, nutrition, or biotechnology). A faculty committee is currently undertaking a thorough review and evaluation of the existing curriculum, with respect to its ability to meet the needs and interests of undergraduates, while remaining a preprofessional program that prepares students for graduate and medical schools. It is expected that the committee will make its report and recommendations during the coming academic year.

CONFERENCES AND SYMPOSIA

The Nineteenth Annual Underwood-Prescott Symposium, entitled "The Impacts of Genetics on the Food and Agricultural Industries," was held on September 22, 1981. This year's awardee, Sir William MacGregor Henderson, was honored in recognition of his contributions to food science through his capable leadership as Secretary to the Agricultural Research Council and his contributions to virology. Sir William's presentation concerned genetic manipulation as a means to increase food production.

The two additional speakers at the symposium were Dr. James Shepard of the Department of Plant Pathology, Kansas State University, who presented a lecture entitled "New Approaches for Enhancing Yield and Disease Resistance in Crop Plants"; and Dr. Raymond Valentine of the Department of Agronomy and Range Science of the University of California at Davis, who presented a lecture entitled "Genetic Engineering of Crop Plants."

In October 1981, the Department sponsored a colloquium entitled "Microcapsules and Microcarriers in Biotechnology" through the auspices of the Industrial Liaison Program. This colloquium was chaired by Professor Robert Langer and co-chaired by Professors Marcus Karel, Alexander Klibanov, and William Thilly. In this colloquium, the use of novel systems -- microcapsules and microcarriers -- in biotechnology was discussed. These developments have significant potential in applications for both basic and applied research. Applications in several important areas were discussed including their use as 1) supports for cells which make useful products, 2) matrices for enzymes to be used as bioproducers or bioconverters, and 3) important components in drug and food

delivery systems. Additional speakers in this colloquium, which was attended by 300 people from industry, government, and academia, included Professor T. Chang of McGill University, Professor E. Katchalski-Katzir of the Weizmann Institute of Science, and Professor D. Papahadjopoulos of the University of California at San Francisco.

FACULTY

Robert S. Langer, associate professor of Biochemical Engineering, was awarded tenure, effective July 1, 1982. He also holds a secondary appointment in Whitaker College. Professor Charles L. Cooney was promoted from associate professor of Biochemical Engineering to full professor.

Dr. R. Alan North was appointed associate professor of Neuropharmacology, having previously held a similar position at Loyola University Medical School. Dr. North received his M.B. and Ph.D. degrees from the University of Aberdeen, Scotland. His research programs deal with mechanisms of action of naturally occurring neurotransmitters and of exogenous drugs and toxins on membranes of mammalian nerve cells.

Dr. Michael Holick joined the faculty as associate professor of Nutritional Biochemistry. He received his Ph.D. (in Biochemistry) and M.D. degrees from the University of Wisconsin, and came to the Department from the Massachusetts General Hospital, where he was associate professor in the Endocrine Unit. His research interests concern mechanisms of action of vitamin D and regulation of calcium metabolism.

Dr. Marsha R. Rosner was appointed assistant professor of Toxicology in February 1982. Having received her Ph.D. in Biochemistry from MIT in 1978, Dr. Rosner was a postdoctoral fellow in the Department of Biology before joining our faculty. Her research involves the study of membrane surface and transport processes as targets or mediators of effects of toxic or carcinogenic chemicals.

Dr. Sanford A. Miller, professor of Nutritional Biochemistry, who had been on leave to serve as director of the Bureau of Foods of the US Food and Drug Administration, resigned his faculty appointment on March 1, 1982, to remain in the FDA position.

Drs. Daniel I.C. Wang and Cooney, professors of Biochemical Engineering, requested transfer of their primary academic appointments to the Department of Chemical Engineering. Their transfers will become effective on July 1, 1982. While their primary academic appointments will be in Chemical Engineering, Professors Wang and Cooney will continue to hold joint appointments in this Department. They intend to maintain active roles in the Biochemical Engineering degree program, acting as advisors to graduate students and also teaching core courses. The Biochemical Engineering degree program will continue to be offered through this Department, although students may also enroll in the program through Chemical Engineering.

Faculty Awards

Several members of our faculty were honored during the past year by receiving various prizes and awards. Dr. Richard Wurtman was the recipient of the Osborne and Mendell Award of the Nutrition Foundation. Dr. Vernon Young was the winner of the Borden Award in Nutrition from the Borden Foundation. Dr. Hamish Munro was the recipient of both the Bristol Myers Award and the Rank Fund Prize. Dr. Wang was selected for the 1981 Food, Pharmaceutical, and Bioengineering Award of AIChE (American Institute of Chemical Engineering). Dr. Nevin Scrimshaw was one of the six members of the MIT faculty who were elected Fellows of the American Association for the Advancement of Science.

GERALD N. WOGAN

Department of Physics

In 1981-82 the total number of faculty members was 95. The number of declared Physics majors (including double-degree candidates) was 262, and full-time graduate students numbered 302. Degrees awarded during the year numbered 81 S.B., 16 S.M., and 42 Ph.D. In spite of financial stringencies, all the major research programs in the Department have remained active and successful, as described in the detailed accounts later in this report.

The following faculty members received promotions during the year: to full professor: John Belcher, Min Chen, June Matthews, and Toyoichi Tanaka; to associate professor: A. Nihat Berker, Elizabeth Hafen, Shimon Levit, Robert Redwine, and J. Scott Whitaker. John Dreher was appointed as an assistant professor.

Visiting faculty during the year were Professors Barry Berman, Charles Holbrow, Kjell Johnson, Julius Kuti, P.M. Matthew, Henri Orland, Ronald Rau, and Anton Zeilinger.

The Department successfully initiated its Physics micro-workshops, conducted with the participation of the electronic industry. The first workshop was on semiconductors; next year the workshop will be on new developments in the field of optics. A summer student industrial program described in earlier reports continues at a modest level.

Professor Victor F. Weisskopf was a co-recipient (with Freeman Dyson and Gerard t'Hooft) of the Wolf Prize, for "outstanding contributions to theoretical physics, especially in the development and application of the quantum theory of fields."

Professor Richard Cohen was awarded a Hartford Foundation Fellowship for biomedical research; Professor Philip Morrison was named as the recipient of the American Physical Society Forum Award. Professor John Joannopoulos was the holder of a Guggenheim Memorial Fellowship. Professor Alan Guth has been given a two-year Sloan Foundation Fellowship. Professor Michael S. Feld received the Gordon Y. Billard Award for his contributions to MIT's Affirmative Action programs. Professor Arthur K. Kerman was appointed as a member of the new White House Science Committee.

In student affairs, a notable development was the establishment of an MIT chapter of Sigma Pi Sigma, the physics honor society associated with the National Society of Physics Students, operated under the auspices of the American Institute of Physics. The charter group numbered 60 members. This year also saw the inauguration of the Orloff Prize for physics seniors, an annual prize given by the parents of Joel M. Orloff, Class of 1978, in his memory. This year the prize was awarded jointly to Gregory Kochanski and Stephen Pollock of the Class of 1982.

Leaves of absence during the year included Professors Claude Canizares, Eric Cosman, Roscoe Giles, Karl Ingard, John Joannopoulos, Kenneth Johnson (fall), Vera Kistiakowsky, Shimon Levit, Walter Lewin (fall), Philip Myers (spring), Stephen Steadman (spring), Edward Wright, and Senior Research Scientist Joseph D. Burger.

Resigning this year were Professor Judith Bostock and Professors Myers and Steadman. The Department also lost (through transfer to the Provost's Office) its senior administrative officer, Daniel H. Gould, who had served in that capacity since 1967. He has been succeeded by John B. Morway, formerly administrative officer for the Center for Space Research.

RESEARCH

Astrophysics

MIT continues to be a major center of astrophysical research as evidenced by both the range and quality of the research program in the Departments of Mathematics, Earth and Planetary Sciences,

and Physics and in the interdisciplinary Center for Space Research. The astrophysics program in the Physics Department is involved with research on astrophysical distance scales extending from the earth to the universe and over an energy range of phenomena extending from 10^{-8} ev to 10^{22} ev.

Highlights of the research of the past year are here organized in a hierarchy of distance from the earth.

I. The Solar System. The Venusian gravitational field mapped by the Pioneer Venus orbiter indicates that the mass distribution inferred from measurements of the Venusian topography is more complex than assumed in simple planetary models.

Data derived from the three-dimensional plasma probes and magnetometers on the Voyager missions to the outer planets are being analyzed. Theoretical work is continuing on the profound effects of the non-thermal high-energy tails in the particle energy distribution functions of the solar wind -- in particular, the relation to coronal holes and the boundary conditions for the solar plasma at large distances from the sun. One puzzle is the fact that the solar plasma appears to cool more slowly than by adiabatic expansion, and it is conceivable that neutrals in the interstellar medium are being injected as an energy source.

Data from the Voyager encounters with Jupiter are yielding models for the interaction of the Io flux tube, which co-rotates with this Jovian satellite, and the ambient Jovian ionosphere. The flux tube appears to behave as an incompressible fluid. At Saturn, the data indicate an inexplicably high energy (100 ev) for the ions in the Saturnian magnetosphere.

II. Stars and our Galaxy. A full general relativistic treatment of the hydrostatic interior solution for a neutron star has been carried out. The relativistic solutions yield changes by factors of 2 to 3 in the modeling of some of the observable parameters of these stars -- in particular, an increase in thermal transport from the stellar interior, and a reduction in neutrino opacity. Ironically, the Newtonian gravitational models fit the observed data better than the relativistic case.

Theoretical and observational work on binary stellar systems continues. SAS-3 data have uncovered 21 binary systems in a search of one-third of the total data accumulated. Optical observations of the 19th magnitude X-ray nova AO 620-00 indicate that tidal distortions in the dwarf star companion play an important role in the formation of binaries. A full dynamical evolutionary theory of binaries has been developed that predicts an 80-minute minimum period for these systems, borne out by observations.

Observations of more irregular time variability in stellar systems continues. Observation of the burst source MXB 1728-34 in SAS-C data indicates that there is a saturation in the burst flux, which imposes strong constraints on the burst models. Simultaneous optical and X-ray observations in MXB 1636-53 are giving evidence for the evolution and dynamics of the accretion disk around a neutron star. Further evidence for the role of the accretion disk in the X-ray luminosity of stars comes from optical observations of the X-ray source HU 2129+47, which is found to be an extended object rather than a compact source. The X-ray emission may originate with a corona intertwined with the accretion disk.

Another black hole candidate has been discovered in the X-ray data from SAS-3. CIR X-1 exhibits variability on time scales as short as 100 msec with an average period of 16 days. This is one of the results of an extensive search in the X-ray data for sources with aperiodic variability.

Research on galactic structure and the interstellar medium has progressed in several areas. MASCOT (MIT Astronomical Spectrometer Camera for Optical Telescopes) used at the 1.5-meter telescope in Chile (a CCD camera-spectrometer) has discovered three very red objects near the galactic center. One of these sources, FNS-1, may indeed be at the location of the galactic center. In the past year, using radioastronomical techniques, isocyanic acid (HNCO) has been detected in the Sagittarius A molecular cloud near the galactic center. The strength of the lines, which are collisionally excited, indicate that molecular hydrogen, the major constituent of the gas in interstellar clouds, is 100 times more abundant in SAG.A than previously supposed. Work has begun on mapping the galactic center region using the Very Large Array (VLA) at its highest frequency (24 GHz). These observations have uncovered small spiral arms (30 sec of arc) emanating from the galactic center.

A model for the astrophysical maser action in silicon monoxide around red giant stars has been developed. The model predicts the observed time scales (100 days) of maser action. The model requires the ejection of material by red giants and subsequent grain formation within 1 to 2 stellar radii, regions of abnormally high density. The model may be tested by optical observations with the new generation of telescopes.

Results of the SAS-3 survey of the soft X-ray background support the view that the background intensity of soft X-rays is the sum of two components. One is emitted by hot gas ($\sim 10^6$ degrees Kelvin) surrounding the solar system, probably the result of an ancient supernova explosion that formed an enormous hot "bubble" near the middle of which the solar system now sits. The other arises from hot gas of substantially less density that suffuses most of the volume of the galactic disc and forms a corona above and below the disc. The anticorrelation between the observed intensity of soft X-rays and the column thickness of neutral hydrogen derived from 21 cm radio measurements is well accounted for in terms of the theoretical model of the interstellar medium, in which most of the neutral hydrogen is concentrated in small, dense clouds of cold gas that are imbedded in the hot gas and that are nearly opaque to soft X-rays.

Further analysis of data on the Puppis A supernova remnant from the MIT Focal Plane Crystal Spectrometer on the Einstein X-ray Observatory (HEAO-2) has demonstrated that oxygen and neon in the ejecta of that stellar explosion are substantially more abundant relative to iron than in solar system material. This work has provided a new test of theoretical predictions of the depth of stellar material thrown off by a supernova explosion.

III. Extragalactic and Cosmological Research. Very Long Baseline Interferometry (VLBI) has been used in mapping the nearby galaxy M81 which appears to have the most compact galactic nucleus ever observed.

High-energy X-ray (E > 20 kev) observations of the quasar NRAO-140, which has a redshift z = 1.2, indicate that it may be the most luminous object, 10^{47} ergs/sec, known. Aside from these extrema, X-ray observations at high energies (E > 20 kev) have been made of the Perseus cluster of galaxies. These data are important in interpreting the millimeter-wave measurements of the comptonization of the cosmic background spectrum by the intercluster plasma, which is believed to be the X-ray source.

Observations and theoretical work are continuing on understanding the gravitational lens formed by a galactic cluster bending the light of a more distant quasar. VLBI techniques have succeeded in showing a third source which may be the bending galaxy or another image of the quasar.

The use of the gravitational lens phenomena as a means of obtaining the cosmological parameters -- g_o, the deceleration and H_o, the Hubble constant -- has been studied, and appears unpromising due to the local mass inhomogeneities of the universe. However, it is possible to set a better-than-now-known limit on the cosmological constant, λ.

New measurements at millimeter and submillimeter wavelengths of the large-scale angular distribution of the cosmic background radiation indicate that the spectrum of the motional anisotropy is appropriate to a thermal source around 3 K. Furthermore, the perturbation of the cosmic background measurements by interstellar dust obeys close to a secant law in galactic coordinates.

IV. Instrumentation and New Projects. The National Science Foundation (NSF) has funded a Dartmouth, Michigan, and MIT collaboration to build a 2.4-meter optical telescope at the McGraw-Hill site on Kitt Peak. The telescope's primary mirror is now being manufactured, and the expectation is that the telescope will experience first light in 1985. The development of modern optical instrumentation for this and other telescopes is well under way at MIT with the development of MASCOT and the construction of a slit-scanning multiband photometer.

A new rocket payload to observe the sky between 50 and 250 Å is nearing completion.

Development of a new type of X-ray detector using HgI_2 is ongoing. This material has higher efficiency and energy resolution than prior X-ray detectors.

Work continues on the engineering and costing of a 1-to-10 km baseline gravitational wave antenna which holds the promise to detect, or set interesting limits on, the gravitational wave spectrum in the 10 Hz-to-10 kHz band.

The Cosmic Background Explorer (COBE) satellite is in an advanced stage of development at MIT, Princeton, the Jet Propulsion Laboratory (JPL), and NASA (Goddard). The project formally scheduled for a new start in the summer of 1982 is now scheduled to fly in late 1988. This mission will measure both the cosmic background radiation spectrum in the millimeter and submillimeter spectral regions and the large-scale angular distribution of the brightness at four wavelengths below the black body peak. It also will make a study of the universe in 10 bands extending from 300 μ to 1 μ.

Atomic, Condensed Matter and Plasma Physics

I. Atomic and Molecular Physics. New results have been obtained in a study of spontaneous radiation from excited atoms. This process is often regarded as being stimulated by zero-point fluctuations in the radiation field; it has been discovered that these fluctuations can be reduced, and the spontaneous radiation inhibited, by placing the atoms in a suitably mistuned cavity. Since spontaneous emission is the fundamental source of noise in quantum electronics devices, the ability to control it has important practical implications. It should also be possible to enhance the zero-point fluctuations in a cavity. Experiments to demonstrate this are in progress.

Powerful new techniques to polarize atomic nuclei through laser excitation and velocity-changing collisions have been demonstrated. Using alkali metal vapors at densities of 10^{16} atoms/cm^3, nearly 100 percent polarization has been achieved. A velocity selective "photon echo" spectrometer has been developed and used to obtain new results about optical polarization preserving velocity changes during collisions in gaseous ytterbium. Calculations of the efficiency of a method to produce coherent millimeter wave radiation from heat sources have been promising, and experiments to demonstrate the method, called photon recycling, are under way.

Most collisions between an atom and a molecule change rotational but not vibrational energy states of the molecule. A theory has been constructed in which angular momentum transfer, rather than rotational-to-kinetic energy transfer, plays the fundamental role. This is able to predict velocity-dependent collision cross sections for a wide range of collisions with 10 percent average error.

II. Biological Physics. Work continues with the aim of understanding the mechanism of the disordered electrical activity that occurs in ventricular fibrillation in the heart. Time-dependent percolation theory and modern theories of the development of chaos appear promising, and experimental studies of the heat-to-beat fluctuations of electrical activity in the heart are in progress.

Laser light heating spectroscopy is being used to investigate the molecular basis for solubilization of cholesterol in bilesalt micelles and the stability of high density lipoproteins. These studies are important for a fundamental understanding of gallstone formation and the transport of cholesterol in the blood.

III. Condensed Matter Physics. The condensed matter theory group has been very successful in developing computational methods for calculating total energies in non-crystalline solids, and has succeeded in calculating the correlation energy of charged defects in glasses while explaining many puzzling properties of these materials. It also has been possible to compute realistically the interactions between an atom and a surface, thereby predicting likely adsorption sites and the diffusive motion of adsorbed atoms on surfaces.

A theory based on the chaotic recurrence of mathematical mapping transformations has been developed which explains the properties of spin glasses and related amorphous materials. A model based on frustrated molecular interactions has been developed to explain reentrant behavior, in which cooling results in a less ordered state in liquid crystal materials.

There has been great progress in experimental investigation and explanation of several phase transitions between the smectic phases of liquid crystals. Reentrant behavior, in which an ordered smectic A phase changes to a less well-ordered nematic state upon cooling, has been carefully measured and quantitatively explained using standard multicritical theory. A transition, smectic A to C phases, which should show critical behavior analagous to superfluid helium, has been found to exhibit classical mean field behavior; this can be explained by a quantitative consideration of the effect of thermal fluctuations. Thus, ideas developed for simpler materials are successfully being used to explain more complex states of matter.

Quasi-elastic light scattering has been used to study the internal modes of a polymer chain near its transition from expanded coil to compact globule. A critical slowing down and divergence of fluctuations has been observed, which suggests that theories of condensed matter phase changes can be applied to elucidate polymer behavior.

An X-ray scattering study (using synchrotron radiation) of the melting of Krypton monolayers adsorbed on graphite showed the transition to be second order, confirming the somewhat controversial predictions of our condensed matter theory group. A similar study of the melting of xenon monolayers on graphite showed, for the first time, the algebraic decay of positional correlation functions and exponential divergence of the correlation length that has been predicted to occur in two-dimensional melting. This confirms one of the most interesting recent theoretical results in statistical mechanics.

Studies of infrared nonlinear optics in semiconductors have revealed a quite general divergence of the nonlinear susceptibility, as the difference between two frequencies being mixed becomes small. This has been used to study electron thermal equilibration times, 10^{-12} second or shorter in several materials. A theory of bound magnetic polarons in finite spin clusters has been developed which successfully predicts the temperature and magnetic field dependence of the spin flip frequency. It also explains the transition from mean field to fluctuation-dominated behavior as the temperature is raised and the magnetic field decreased.

It was predicted nearly 25 years ago that the quantum state of an electron in a random potential would change from localized to extended at a particular energy, called the "mobility edge." This has never been verified experimentally, but recent photoluminescence experiments carried out at MIT in an amorphous semiconductor suggest that it may be observable. Further experiments are in progress.

Research to create spin polarized atomic hydrogen was described in last year's report; this will be an interesting new quantum fluid -- a superfluid gas. This year a major breakthrough occurred, and the MIT group succeeded in producing hydrogen with nuclear as well as electron spin polarization. This greatly increases the lifetime of the atomic state and the chances of achieving high enough densities to observe the superfluid transition.

Work has continued in the collaboration with Honeywell on possible detection of the magnetic vector potential, using Josephson detector devices. State-of-the-art superconducting thin-film interferometers (0.2 μm) have been produced, and a large torus source of $\underset{\sim}{A}$ has been designed and tested.

IV. Plasma Physics. The toroidal confinement scheme of a tokamak is one of the most promising for plasma fusion. It has been clear for some time that practical tokamaks will have to be operated in a continuous mode. Recent experiments at Versator II at MIT have indicated that radio frequency power can continuously drive the plasma current for low-density plasmas. Experiments are now beginning with a one megawatt r.f. source at much higher densities in the Alcator C tokamak. Numerical computations by the plasma theory group can explain most of the r.f. current drive experiments in Versator II. Theoretical work has also shown that energy confinement scaling laws developed for smaller tokamaks should be applicable to predicting behavior in Alcator C.

There has also been a theoretical explanation of the enhancement of electron thermal conductivity observed with auxiliary, non-ohmic, heating schemes in tokamaks. Predictions are that an undesired "internal kink" instability of the plasma in a tokamak will disappear at high values of the parameter β (the ratio of kinetic to magnetic energy of the plasma).

The intense relativistic electron beam group has developed two novel types of free electron lasers, the LOBITRON and the RIPPLED-FIELD MAGNETRON, for generating intense, coherent electromagnetic radiation in the millimeter and submillimeter wavelength ranges. In both devices stimulated emission is achieved by a spatially periodic magnetic field acting on a stream of monoenergetic electrons. The analytic studies carried out during the past year are being followed by experiments and computer simulations.

Experimental Nuclear and Particle Physics

I. Heavy Ion Group. Research in the heavy-ion group has been focused on understanding the dynamic processes initiated when two atomic nuclei come together. The experiments, performed primarily at Brookhaven National Laboratory, include the continuation of pioneering studies of the resonances occurring in systems of identical, light heavy-ions, and of the extensive sub-barrier fusion and accompanying nuclear structural variations observed when massive nuclei fuse. A new, state-of-the-art Recoil Mass Selector, built at MIT, is being installed at the Holifield Heavy-Ion Research Facility at Oak Ridge.

II. Medium Energy Physics. Research in this broad area at the boundary between nuclear and particle physics is concentrated at the MIT Bates Linear Accelerator, where electron and photon beams of energy up to 400 MeV (soon to be increased to 750 MeV) are available. Complementary experiments with proton and pion beams at the Indiana University Cyclotron Facility and the Los Alamos Meson Physics Facility are also being performed.

At Bates, a high-resolution magnetic spectrometer and sophisticated detection system have been employed to study elastic and inelastic scattering of electrons from few-nucleon systems and complex nuclei, giving precise data on the charge and magnetization structure of nuclei. These provide a standard for the testing of theoretical models. Some of these results, when combined with those from proton-scattering experiments, have been used to gain a better understanding of the effects of the nuclear medium on the nucleon-nucleon interaction.

In the process known as "deep inelastic" scattering, incident electrons lose energy through interactions with individual nucleons bound in the nucleus. Measurements of the energy spectra of the outgoing electrons have yielded information on nucleon wave functions and on the correlations between nucleons such as those mediated by the exchange of mesons.

Similar aspects of nuclear structure have been probed in experiments using a photon beam to remove nucleons from nuclei or to produce pi-mesons. For example, a photon of energy around 300 MeV incident on a nucleus can excite the first pion-nucleon resonance [the $\Delta(1232)$]. The pion thus created may either escape from the nucleus or be reabsorbed, the latter process generally resulting in the ejection of one or more energetic nucleons. Experiments in which the photoprotons are observed have been performed; the important complementary photoneutron measurements are just beginning. The observation of charged and neutral photopions yields valuable information on both the fundamental production amplitudes and on the propagation of pions within the nuclear medium.

In related work carried out at Los Alamos, pion scattering, adsorption, and charge exchange processes have been investigated to further our understanding of meson-nucleus interactions, as well as to provide new data on nuclear structure. For example, the pion double-charge exchange reaction [$A(\pi^+,\pi^-)B$] necessarily involving two nucleons, is expected to be particularly sensitive to nucleon-nucleon correlations.

Besides these studies of complex nuclei, there is also ongoing work at the Bates Laboratory on fundamental interactions. Preparations are under way to measure the parity-violating asymmetry in the elastic scattering of longitudinally polarized electrons, so as to explore the phenomenon of weak neutral currents as predicted by, for example, the Weinberg-Salam-Glashow model of the electroweak interaction. The nature of the nucleon-nucleon force is being studied by observing the tensor polarization (alignment) of the recoil deuteron in the elastic electron-deuteron scattering process. Work is proceeding on a precise measurement of the cross section for the photo- and electro-disintegration of the deuteron, which, together with a study of the outgoing nucleon polarization, will yield further insight into the mesonic, baryonic, and dibaryonic degrees of freedom of the nucleon and the two-nucleon system.

III. High-Energy Groups. The Counter Spark Chamber Group has continued its Fermilab-based program of studying the structure of the nucleon and the structure of the weak interaction using neutrinos as a probe. Analysis has proceeded on the study of mu neutrino-electron scattering data obtained in last year's run. New data are currently being obtained from which the structure functions of the nucleon, as sensed by the weak neutral current, will be extracted. These results will allow detailed comparison with the expectations based on other data and the predictions of weak-electromagnetic unified theories (e.g., the Weinberg-Salam theory).

The APC (Accelerator Physics Collaborative) Group is conducting experimental research on the nature and interactions of photons and hadrons. The experiments are performed at two of the country's National Accelerator Laboratories: the Stanford Linear Accelerator in California, and the Fermilab Accelerator in Illinois. In one of the experiments at Stanford, pi-mesons were used to bombard protons in an effort to learn the role that pi-mesons play in acting as the "quanta" of that part of the nuclear force that affects grazing collisions. The pi-mesons acting as quanta of the field behave similarly to real physical pi-mesons. The other Stanford experiment is still in progress. Its goal is to see how photons, which are massless vector quanta of the electromagnetic force, change into vector mesons, which are massive quanta of the nuclear force.

An experiment at Fermilab, just completed, was designed to study how hadrons made up of one set of quarks generate hadrons with other types of quarks, or other combinations of the same types of quarks. For this study, a unique device was developed that identifies each particular type produced. The device, called CRISIS, worked well and should give information never previously available.

An experiment has been approved for running at Fermilab in 1985, the apparatus for which is being designed and built now. The goal of the experiment is to search for a hitherto undiscovered particle, the tau neutrino. Proof or denial of its existence will have major theoretical implications.

All of these experiments are being done in collaboration with a consortium of universities in Japan, Italy, France, Israel, and the United States. The APC group, which has been the organizer of the consortium and of the experiments, has four faculty members, three postdoctoral physicists, nine graduate students, and eleven undergraduate students, as well as programmers, engineers, film scanners, technicians, data analysts, and secretaries.

The EMI (Electromagnetic Interactions) Group has continued to take data at the electron positron collider PETRA at a center of mass energy of 35 GeV. This year, enough data were collected to measure weak neutral current effects in the process $e^+e^- \rightarrow \mu^+\mu^-$ for the first time. This is the highest q^2 measurement of weak effects to date, and therefore puts significant model-independent limits on the mass of the intermediate neutral vector boson, the Z^O. The higher order QED process $e^+e^- \rightarrow e^+e^-\mu^+\mu^-$ was also measured, and several searches were made for new particles which are expected in various unified theories of physics.

In October 1982, PETRA will increase its energy to 41 GeV, permitting the search of a new mass region for new quarks and leptons.

The EMI group, in conjunction with a large worldwide collaboration, has proposed a new experiment for the LEP collider at CERN (Centre European pour Recherche Nuclée). This collider would be able to produce the Z^O and measure its properties. The EMI group's existing detector is ideally suited for studies of the Higgs particle that may be produced along with the Z^O, as well as measuring the rate of decay of the Z^O into neutrino pairs -- thereby determining the total number of fermion families that exist.

Nuclear Theory

Nuclear theory research during the past year furthered our understanding of nuclear structure, forces, and dynamics. Two central themes have been the mean field theory of nuclear collective motion and the role of nucleon degrees of freedom (mesons and/or quarks) in nuclear physics. Some specific research efforts are indicated below.

I. Electromagnetic Interactions in Nuclei. Scaling in deep inelastic electron-nucleus scattering has been examined, focusing upon the relation between the structure function and the nucleon momentum distribution. The conventional argument, based upon the impulse approximation, is found to be incorrect for systems with strong repulsive interactions. Further, a transition from nucleon scaling to quark scaling is found at high energy.

Meson exchange current contributions have been included in calculations of electroexcitation of nuclear particle-hole states, particularly high spin states in heavy nuclei. Production of hypernuclei by the (γ,K) reaction has been calculated.

II. Nuclear Reactions and Medium Energy Physics. The cascade approach to nuclear reactions has been derived from the statistical multi-step direct reaction theory developed earlier.

A serious apparent discrepancy between the nucleon mean free path computed theoretically and the path extracted phenomenologically has been explained. Consistency between theory and experiment is achieved with proper inclusion of the optical potential nonlocality.

The formalism for pion-nucleus reactions including pion annihilation/production via the $\Delta N \rightleftarrows NN$ mechanism has been developed. The Δ-nucleus spreading potential strength and its origin in pion annihilation have been explained microscopically. The associated strong ΔN collision amplitude has been shown to modify significantly both nucleon knockout and nuclear p-h excitation in pion scattering.

Intermediate energy pion-nucleon bremsstrahlung has been calculated in a dynamically consistent, gauge invariant model, leading to a value of the bare Δ^{++} magnetic moment $\mu(\Delta^{++}) \tilde{\sim} 2.7\ \mu(p)$.

III. Many-Body Theory and Nuclear Collective Motion. It has been shown that a Feynman diagram perturbation expansion can be used for a time-dependent unperturbed Hamiltonian. Systematic corrections to the time-dependent Hartree-Fock approximation can be evaluated.

Monte Carlo methods for calculating certain observables in the many-fermion problem have been developed. Effort thus far has resulted in techniques for solving for ground states and fission lifetimes in one spatial dimension.

A general method for constructing path integrals for the nuclear many-body problem, using continuous and overcomplete sets of vectors in the Hilbert space, has been developed. These techniques provide a formal solution to the problem of calculating cross sections from the time-dependent Hartree-Fock equations. Nuclear level densities have been evaluated via mean field functional integrals.

A "Born-Oppenheimer" method to describe large-amplitude collective motion has been developed. Several collective variables can be treated by the method.

IV. Nuclear Structure and Heavy Ion Reactions. The interacting boson model (IBM) has been analyzed in a classical framework. Expressing the classical IBM Hamiltonian in conventional geometrical variables, the nature of the static equilibrium configurations and the dynamics about that equilibrium in the three limits of the IBM have been explained. The relationship of the giant monopole resonance in finite nuclei to the nuclear matter compressibility has been examined, with emphasis on the role of the nuclear surface.

Matter and momentum flow during heavy-ion collisions was studied via numerical evaluation of the Wigner phase-space distribution function.

V. Nuclear Forces and Quark Models. The R-matrix approach to combining the short-range quark degrees of freedom and the long-range hadron degrees of freedom in the description of hadron-hadron interactions was investigated. Numerical studies have proceeded for the $^1S_0$ NN channel. A potential model for composite systems with exchange symmetry, confinement, and no van der Waals forces has been developed. Scattering phase shifts have been calculated, showing strongly inelastic resonances in some cases, and hard-core behavior in other cases.

Particle Theory

Research during the past year has focused on gauge field theories and their role in our description of the fundamental interactions. Our efforts may be divided broadly as follows: I) structure of gauge theories; II) applications to theories of electroweak and grand unified interactions, especially as to their cosmological implications; and III) applications to quantum chromodynamics and models of hadronic structure and interactions. Some of the more important developments are described more fully below.

I. Structure of Gauge Theories.

a) The physical interpretation of fractionally charged solitons in non-Abelian gauge theories has been clarified. Professors Jackiw and Rebbi showed several years ago that such solutions may exist. Examples from solid-state physics displaying 1/2 and 1/3 integer charge have subsequently been described and, in at least one case, observed.

b) Symmetry breaking, mass generation, and the structure of infrared divergences have been studied in three-dimensional Yang-Mills theories and related models. In particular, a mechanism for generating masses without destroying gauge invariance has been described and explored in several three-dimensional models.

c) Supersymmetric nonlinear sigma models in two dimensions have been studied extensively. Certain models have been shown to be ultraviolet finite to all orders in perturbation theory. The breakdown of supersymmetry and the problem of mass generation have been studied in two-dimensional models. The insights and methods developed in two dimensions are being applied to the physical case of four-dimensional space-time.

d) A remarkable equivalence between quantum field theories in D-dimensions and stochastic classical field theories in D+2 dimensions has been studied, extended to new models, and used as a regularization method.

II. Electroweak and Grand Unified Theories.

a) The cosmological implications of grand unified theories have been pointed out and explored. The "inflationary universe" scenario of cosmogenesis originally developed by Professor Alan Guth has been developed extensively. The viability of a new version of this scenario has been studied and confirmed.

b) A confined model of the electroweak interactions, the only known viable alternative to the Weinberg-Salam-Glashow model, has been developed and its phenomenological implications studied.

c) Dynamical mass generation in models of electroweak interactions has been studied in an ongoing attempt to understand fermion masses and the apparent mass hierarchies of gauge interactions.

III. Quantum Chromodynamics (QCD) and Hadron Dynamics.

a) A conceptual framework for modeling the vacuum and low-lying states of QCD is being developed. Both short-range order in color (confinement) and long-range chiral order are incorporated by exploiting localized wave functions such as appear in condensed matter physics.

b) The P-matrix analysis of low-energy scattering has been developed into a practical method for analyzing data in a way which makes direct contact with the predictions of confined quark models.

c) Violations of scaling in inelastic electroproduction due to non-perturbative ("twist-4") effects have been completely analyzed. Their interpretation has been clarified by relating them to the parton model.

d) Practical methods for carrying out perturbative calculations with confined QCD have been developed. The methods are sufficiently convenient to allow computation of important higher order effects which heretofore have been impossible to calculate.

HERMAN FESHBACH

Experimental Study Group

ESG had another active year, attracting students and staff interested in participating in an informal academic community of more than 100 people engaged in cooperative education. This past year, 44 freshmen, 25 sophomores, and 4 transfer students registered for one or more terms in ESG. On the average, the freshmen completed 48 units each term, taking 2.5 subjects in ESG and 1.7 subjects in the regular curriculum. The percentages of women, black, and international students registered in ESG (34 percent women, 9 percent black, and 8 percent international students) were once again higher than the corresponding percentages for the MIT freshman class. Last year's freshmen in ESG achieved a relatively high cumulative grade point average of 4.3 in their sophomore year, three-quarters continuing to take one subject per term in ESG. The four transfer students used ESG's flexibility to solidify basic science and math subjects while adjusting to their departmental programs.

Administration

Professor Robert Halfman, in his eighth year as director of ESG, oversaw the academic operation of the program. Holly Sweet was promoted to associate director in January 1982, and continued

to be centrally involved in all administrative aspects of ESG. The Advisory Committee, which met twice during the year to discuss staffing and general policies, will miss deeply the contributions of Dean Robert Alberty and Professor Jean Jackson, who resigned near the end of the year.

Staffing and Subject Offerings

The usual core areas of mathematics, chemistry, physics, and humanities and social sciences were offered in ESG through a combination of tutorials, supervised independent study projects, and small seminars. Seventeen part-time staff members, drawn from their respective MIT departments, were supported by 27 undergraduate tutors in providing teaching services to the students in the program. The mathematics staff was headed by Dr. Barry Cipra, and included two graduate students, Joshua Bernoff and Dominique Haughton. The physics staff was composed of Professor, Emeritus Nathaniel Frank, Dr. Carl Gardner, and Professor Halfman, and included two graduate students, Peter Dourmashkin and Eduardo Olaguer. Professor, Emeritus Clark Stephenson taught 5.60 and oversaw the tutoring of 5.40, and Ioannis Papayannopoulos (chemistry graduate student) taught a 5.41 recitation section in ESG.

This past year was remarkable for the strength and diversity of the ESG humanities program. The humanities staff was larger than usual because of increased funding recommended by the Advisory Committee. The humanities staff was headed by Dr. Janet Murray and included Professr Stephan Chorover and Ms. Sweet, as well as four graduate students: Susan Rothstein, Richard Sclove, Robert Stoops, and Peter Trubowitz. Following the recommendations of the Advisory Committee to offer more humanities distribution subjects in each of three main areas of humanities and social science (literature, social science, and linguistics and philosophy), ESG offered nine humanities subjects, over half of which received distribution credit: Fantasy Fiction, Introduction to Fiction, Alternative Technology, US Foreign Policy Since 1945, Introduction to Psychology, Three Approaches to Psychology, Linguistics, Introduction to World Religions, and Writing Workshop.

Community Activities

The sense of community was stronger in ESG this year for a number of reasons. More interest was exhibited by both staff and students in non-credit seminars and activities, ranging from mathematical logic and social ecology seminars to French conversation classes, text editing instruction, and piano lessons. Thirty-six percent of the freshmen and a number of the upperclassmen and staff members chose to take part in one or more of these activities. An extensive IAP (Independent Activities Period) program was run, which included 14 different activities sponsored by ESG for the first time. Over 300 people from the MIT community participated in these activities. Five weekend trips for new students and their advisors were made to New Hampshire in the fall, a continuation of a highly successful pilot program developed last year. One of our staff members, Mr. Bernoff, won the Stewart Award for substantial extracurricular contributions to the ESG community this past year.

Students and staff were also actively involved in debating two major policy issues: a name change and a change in distribution of internal credit. A strong push for a new name which would more accurately reflect today's program was eventually defeated by the community. An exploration of alternative modes of handling internal credit for less formal learning produced no changes in procedures, but did reemphasize and clarify some of the traditional values of ESG.

Overview

In President Gray's annual report last year, he wrote that "to succeed in our educational mission, we must endeavor to bring students to intellectual independence--the state in which they can respond effectively to intellectual novelty and can proceed both to form meaningful questions and to seek informative answers to situations which go beyond their prior experience and formal education." ESG has attempted to provide that kind of atmosphere to both its students and staff through a flexible approach which encourages them to take responsibility for their own learning in a creative non-hierarchical fashion. The extensive tutorial interactions, the lively seminar discussions, and the numerous student initiatives would delight ESG's founder,

Professor George E. Valley, who wrote in 1969, "I was interested in fostering students who would be courageous enough to think in new ways without fear of getting the wrong answer."

ROBERT L. HALFMAN
HOLLY B. SWEET

Interdisciplinary Science Program

The Interdisciplinary Science Program (Course 25) is sponsored by the School of Science with the intent to provide special opportunities for undergraduate students 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. The continuation of the undergraduate program is under review due to a declining enrollment.

This past academic year, the Interdisciplinary Science Program has awarded undergraduate degrees to five students. Two degrees were awarded in Cognitive Science, one in Artificial Intelligence, and two in Meteorology. One of the Cognitive Science students graduated Phi Beta Kappa. Seven S.M. degrees were also awarded this past academic year. Since the experimental Interdisciplinary Science graduate program was not granted permanent status during the past year, the remaining students are completing their degrees. Two degrees were awarded in Animal Cell Science, three in Biomedical Science, and two in Science Communication. The three remaining students expect to graduate in September 1982.

JOHN M. BUCHANAN

Center for Cancer Research

During the past year, the Center for Cancer Research has been honored by the election of Professor Phillips W. Robbins to the National Academy of Sciences. Professor Phillip A. Sharp was appointed associate director of the Center for Cancer Research. Professors Robert A. Weinberg and Nancy H. Hopkins have been promoted to full professorships. The work of Professor Weinberg on the isolation and transmission of oncogenes has received worldwide recognition. Oncogenes can be demonstrated in cancer cells by transferring their DNA to normal cells in culture, thereby becoming cancerous cells. Such genes have actually been isolated from many human cancers, and their relation to normal genes is now being explored.

Professor Herman N. Eisen was appointed Whitehead Professor of Immunology at MIT. Professor Frank Solomon was awarded tenure during the year. Professor Salvador E. Luria has been appointed chairman of the Committee on Biological Research on Radiation of the National Research Council. Professor Richard C. Mulligan has joined the faculty of the Center for Cancer Research.

Professor Michael Bevan, a leading authority on cellular immunology, left MIT in 1982. Professor Bevan, who suffered serious allergies throughout his stay in Boston, chose to relocate to a senior position at the Scripps Clinic and Research Foundation in La Jolla, CA.

Visitors of faculty rank in the Center during the past year have been: Dr. Samuel Latt (Harvard Medical School), Dr. Tai Te Wu (Northwestern University), Dr. Kenneth Kidd (Yale University), and Dr. Standish Hartman (Boston University). All were appointed as visiting scientists in the Center for Cancer Research.

SALVADOR EDWARD LURIA

Center for Space Research

The MIT Center for Space Research (CSR) conducts an active program of research in space science and technology, with emphasis on experimental and theoretical investigations in support of various NASA missions. A major part of this program concerns the analysis and interpretation of data from flight experiments. Specific areas of research include X-ray astronomy, interplanetary plasma, magnetospheric plasma physics, the life sciences, properties of planetary surfaces and atmospheres, and radio astronomy. The Center is currently engaged in the design and development of experiments to support several long-range flight programs sponsored by NASA; however actual launch dates for almost all of these missions are uncertain because of uncertainties in the NASA funding and in the flight schedule for the Space Shuttle. For this reason there has been little construction of actual flight hardware during the past two years, and our major activities have centered on data analysis and the development of techniques and instruments which will be needed for future missions. During the past year, the Center has been increasingly involved in the development of modern instruments for use at ground-based optical telescopes. The development of these instruments has resulted in a major increase in our ground-based observing program. The long-range NASA program includes several missions in which MIT and CSR are heavily involved. Among these are a large X-ray telescope, the Advanced X-ray Astronomical Facility (AXAF), a large area X-ray timing experiment, and a plasma experiment for the OPEN program (Origin of Plasma in the Earth Neighborhood). An overview of CSR activities during the past year follows.

X-RAY ASTRONOMY

Satellite-Borne Experiments for X-Ray Astronomy

The data archives from four MIT X-ray astronomy satellite projects continue to provide a rich source of material for investigations of galactic and extragalactic X-ray sources. These projects are the SAS-3 X-Ray Observatory, operated under the direction of Professor George W. Clark from May 1975 until April 1979; two experiments on the HEAO-1 satellite, operated from August 1977 to January 1980 and directed by Professors Walter Lewin and Hale Bradt, respectively; and the MIT Focal Plane Crystal Spectrometer on the Einstein Observatory (HEAO-2), operated from November 1978 to April 1981 under the joint direction of Professors Clark and Claude R. Canizares. Among the studies carried out during the past year are a comprehensive survey and analysis of the low-energy X-ray sky by Dr. Frederic Marshall, investigations of the dynamical properties of binary X-ray pulsars by Dr. Richard Kelley, inspection of the spectra and variability of high-energy X-ray sources by Dr. Alan Levine, and an analysis of the X-ray optical and radio properties of Seyfert galaxies and quasars by Dr. Gerard Driss.

Balloon-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. On June 28, 1980, a test balloon flight was conducted which used a small array (approximately 8 cm^2) 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. The ultimate objective is the use of these detectors in various experiments to be carried on future space missions. This test flight not only achieved its technical objectives, but a serendipitous discovery was the finding that the black hole candidate Cyg X-1 had made a transition from its "low state" to its "high state," an event which has only been observed twice before in the history of X-ray astronomy.

Following the June 1980 flight, a new optimally shielded "flight prototype" for the HgI_2 detector, intended ultimately for the Hard X-Ray Diffraction Telescope (HXDT), was constructed and

successfully flown on May 8, 1982. The HXDT was selected by NASA for eventual definition as a Spacelab experiment. During a 31-hour balloon flight, extensive data relating to the effects of highly energetic cosmic ray primaries were obtained, providing critical information required for optimizing an eventual satellite-borne instrument. A follow-up flight with this same instrument is planned for late June 1982. 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.

Rocket-Borne X-Ray Experiments

During the past several years, the MIT X-Ray Astronomy Sounding Rocket group, under the direction of Professor Saul A. Rappaport, has designed and constructed a new wide-field soft X-ray camera. The instrument features three nested Wolter-Schwarzschild grazing incidence mirrors, and a 50 mm diameter microchannel plate imaging detector at the focal plane. The camera has an 8° field of view and is sensitive over the energy range 50Å-250Å. We plan to use this instrument to carry out an all-sky survey in this relatively unexplored wavelength band. It is expected that important new astrophysical information will be obtained for a wide range of astronomical objects. The payload is scheduled for a rocket launch from the White Sands Missile Range early this fall. A satellite experiment, with its longer exposure times, would enable a truly high-sensitivity all-sky survey to be carried out using this technique. Accordingly, a scaled-up version of this instrument has been successfully proposed by a consortium of British astronomers as an ancillary experiment on the German satellite ROSAT.

Optical Studies of X-Ray Sources

During the past year, a new focal plane instrument with CCD (charged-coupled device) detectors was used at the McGraw-Hill, Cerro Tololo, and Mauna Kea observatories. The instrument, which functions both as a direct imaging camera and a spectrometer, was developed under the direction of Dr. Ricker. In previous years, the main thrust of the observing program has been to determine the nature of the old-population X-ray binaries. The current program, which is being carried out by Dr. Jeffrey E. McClintock and Ronald Remillard, is a photometric search for orbital periods in these systems using both the CCD imaging camera and a scanning-slit photometer which was developed in 1980. Another optical program involves the identification and study of quasars and active galaxies initially located through X-ray observations with the Einstein Observatory. A total of 45 objects have been identified by Dr. Kriss and Professor Canizares.

Observations of Interplanetary and Magnetospheric Plasmas

The IMP-8 spacecraft was launched in 1973 into an eccentric earth orbit. It has provided a continuous database of solar wind plasma conditions at 1 Astronomical Unit (AU) for the past nine years. At the present time, there are no other operational solar wind experiments in earth orbit. Thus, the IMP-8 results constitute the only available database. The data are processed routinely, and are used by many investigators for various studies of solar wind properties.

Solar wind data are also being routinely received and analyzed from the Voyager 2 spacecraft, which is now well beyond the orbit of Saturn. Voyager 2 flew past Saturn in August 1981, and will encounter Uranus in January 1986. If the spacecraft is still operational at that time, NASA plans to direct it to an encounter with Neptune in August 1989. Some scientific results obtained from Voyager data during the past year are discussed in the Physics Department's section of this *Report*.

Physics of Space Plasmas in the Earth's Magnetosphere and Ionosphere

In August 1979, a program of theoretical research on the 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: diffuse, discrete, and flickering aurora; magnetic merging and reconnection in the magnetotail, 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; VLF whistler modes; lower- and upper-hybrid instabilities; the trapping and precipitation of energetic charged particles; and beam plasma interactions and ballooning modes in the low-latitude ionosphere. Dr. Tom S. Chang, and Professors Bruno Coppi and Stanislaw Olbert are involved in this program.

Spacelab Vestibular Experiments

This program, being carried out under the direction of Professor Laurence Young of the Department of Aeronautics and Astronautics, will provide a series of experiments 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 equipment have been delivered to NASA for the Spacelab-1 mission (SL-1). Astronaut training is currently in progress with this equipment, which is scheduled to fly in January 1984. During the past year, an upgraded version of these vestibular experiments was selected to fly on both the German D-1 Spacelab mission (launch scheduled in April 1985) and the NASA Life Sciences Spacelab-4 mission (scheduled for November 1985). CSR is currently negotiating contracts for both of these missions. For each mission, 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 and motion sickness susceptibility experiments will be conducted to provide an understanding of the problems experienced by astronauts in the Apollo, Skylab, and Space Shuttle missions. Professor Young is assisted in these Spacelab experiments by Drs. Charles Oman and Byron Lichtenberg 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 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 has been fabricated at CSR and is currently being tested prior to delivery to the University of Hawaii, for evaluation using ground-based telescopes there. The research program is under the scientific direction of Dr. Thomas B. McCord of the University of Hawaii. Supervision of the technical program at MIT 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 diameters. 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.

Venus Mapping Mission (VMM)

The main purpose of this new NASA mission to Venus (formerly the Venus Orbiting Imaging Radar Mission - VOIR) 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 approximately 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. The VMM is currently under study by NASA to see if it is a suitable substitute for the VOIR Mission which was deleted in fiscal year 1982.

THEORETICAL ASTROPHYSICS

Our major expansion of the theoretical astrophysics group is now complete. Professor Charles Alcock and Principal Research Scientist Anna Zytkow arrived at MIT during the past year. Two postdoctoral fellows, Dr. Steven Balbus and Dr. Stephen Kent, also began terms of residence with us. They join Professors Lennox Cowie, Paul C. Joss, Philip Morrison, and Scott Tremaine to form a large and vigorous research group. The research activities of this group are described elsewhere in this *Report*. This new group, which is supported largely by CSR, is already developing strong interactions with our experimental programs.

OTHER DETECTOR AND INSTRUMENT DEVELOPMENTS

Mercuric Iodide Detector Development

Three 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 HgI_2 X-ray spectrometer under development for AXAF and other missions, and for the balloon-borne HgI_2 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 ten 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

Artificial multilayer diffractors, prepared at the IBM Watson Research Center by vacuum deposition of alternate layers of metal and carbon, have been tested for possible use in a focal plane crystal spectrometer for the AXAF. Several of these have been found to have sufficiently high reflectivity and resolution to qualify them as promising diffractors for spectroscopy of low-energy X-rays in the wavelength range where natural crystals with large 2d spacings, such as RAP, exhibit anomalous behavior due to their oxygen content. This work is being carried on by Professors Canizares and Clark.

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 CCDs. The research group involved in this project includes Drs. John Doty, Marshall Bautz, and Stephan Meyer. 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 8 mm. 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.

In mid-1981, MASCOT became fully operational, and since that time it has been used for more than 100 nights on the McGraw-Hill Observatory 1.3 m telescope, the Cerro Tololo Interamerican Observatory (CTIO) 1.5 m telescope, and the Mauna Kea Observatory (MKO) 2.2 m telescope, as well as on the Wallace and MKO 0.6 m telescopes. Numerous astronomical discoveries were made by the approximately 20 MIT observers involved in its use during that period. Scientific results have been reported at six national and international meetings, and a number of papers are already scheduled for publication in astronomical journals during the coming months. (Further details are given in the description for the Wallace Observatory and the McGraw-Hill Observatory.)

In May 1982, a computer-controlled "autoguider" facility was added to MASCOT, significantly increasing its flexibility and ease of use. In its initial use at MKO, it provided image stabilization of ~0.1 arc sec rms. Following its initial implementation on the MKO 0.6 m telescope, the autoguider was successfully used in observations with the MKO 2.2 m and McGraw-Hill 1.3 m telescopes, demonstrating that the design is "telescope-independent" as originally intended.

In 1982 Dr. Ricker and his collaborators undertook the design of a "MASCOT II" which will be a prime-focus CCD imager for the new 2.4 m McGraw-Hill telescope. By more suitably optimizing the match between the image focal plane scale and the "seeing disc" size typically encountered at Kitt Peak, this instrument should allow the imaging performance of the new 2.4 m telescope to rival that of the Mayall 4 m telescope (also at Kitt Peak).

Development of an X-Ray Objective Grating Spectrometer

Professor Canizares and Mark Schattenburg, in collaboration with Professor Henry Smith at the Center for Materials Science and Engineering, have pursued the development of ultra-fine objective gratings for possible use in X-ray spectroscopy on AXAF. Promising results have been obtained in the fabrication of grids having up to 5,000 lines per mm and large ratios of depth to spacing.

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. The European Space Agency (ESA) has authorized a mission to Halley known as the Giotto Mission. The investigation is now under the leadership of Professor Johannes Geiss of the University of Bern. Limited funding has been made available by NASA for US investigators on this mission, and a group led by Dr. Marcia Neugebauer of the Jet Propulsion Laboratory submitted a successful proposal. Dr. Alan Lazarus and Professor Herbert Bridge are co-investigators.

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, the Interplanetary Physics Laboratory (IPL), at the libration point upstream of the magnetosphere. A plasma experiment proposed jointly by the Goddard Space Flight Center and MIT has been selected, and preliminary design is in progress.

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 a final selection of the experiments is expected in the near future.

HERBERT S. BRIDGE

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. It is intended to serve as a facility and resource for cell biologists throughout the United States.

The Center is headed by Professor Phillips W. Robbins of MIT, principal investigator, 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, 1981 to June 30, 1982, the Cell Culture Center provided cells and/or virus material to 31 research groups throughout the United States. Cells are produced either in suspension culture or as roller bottle cultures. During this period, the demand for roller bottle cultures decreased while requests for suspension cultures increased. Total cells produced (approximately 5×10^{12} cells) increased by 20 percent over the previous year. Examples of projects completed during the past year include: 110 roller bottles (RB) of CHEF-18 cells for the Sidney Farber Cancer Institute in Boston, 70 RB of C1-1 cells from MULV production for

MIT, 275 RB of SV-3T3 cells for Tufts University, 585 liters of HeLa S-3 cells for MIT, and 2240 RB of SV-80 cells for the University of Illinois in Urbana.

Other projects included 600 RB of CV-1 cells for Harvard Medical School, 635 RB of BHK cells for the University of Oregon in Portland, 100 liters of lymphocyte cells for the University of Washington in Seattle, and 200 RB of human fibroblast cells for the Massachusetts General Hospital.

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

At the Cell Culture Center, a great deal of emphasis has always been placed on the importance of improving the existing technology for large-scale cell production. Most of our research and development efforts have centered around the development of the microcarrier system for the large-scale production of animal cells and their products. Levine *et al.* discovered that the surface charge on microcarriers was a critical factor for the attachment and growth of anchorage-dependent cells. By controlling the surface charge on microcarriers, they found that virtually all animal cells could be grown to high densities in a stirred tank configuration. Growing cells in suspension on microcarriers offers many advantages over the more conventional methods such as roller bottles and various types of flasks including the following:
1) higher surface to volume ratio
2) easier monitoring and sampling
3) lower cost
4) more homogenous product
5) capability for instrumental control.

Following the development and characterization of the new microcarrier, a series of studies began to examine a number of potential applications of microcarriers, including large-scale production of viruses and fibroblast interferon. The virus production study showed that microcarriers could be used for large-scale production of viruses, and therefore had potential application for vaccine production.

An extensive amount of work has been done at the Center to determine the possible value of microcarriers for use in the large-scale production of interferon. The first study showed that microcarrier-grown cells could be used successfully to produce high titers of human fibroblast interferon. Subsequent studies, including work done in the past year, examined a wide variety of parameters affecting interferon production, and attempted to optimize conditions for interferon production with microcarrier-grown cells. The culmination of these studies was the development of a highly improved low-cost method for large-scale human fibroblast interferon production.

Another important area of research at the Center is the development of improved instrumentation for animal cell culture. Instrumentation studies have centered around the development of an experimental system utilizing a microcomputer for data acquisition and analysis. The computer is interfaced with sensors for the measurement of dissolved oxygen tension, pH, temperature, rpm, and conductance. Data are collected and analyzed for assessment of various metabolic activities as well as cell growth rates. One of the primary uses of the system in the past year has been to monitor the growth and metabolism of a human fibroblast cell line (FS-4), which is the principal line used in our studies for interferon production.

Cell Sorter Laboratory

During the past year, usage of the Cell Sorter Laboratory was well balanced, with approximately 50 percent usage by MIT and 50 percent by external researchers. A new computer, the Ortho Diagnostic 2150, was added to the system to greatly expand data-handling capabilities, and to provide more sophisticated output and statistical analysis. Examples of active cell sorter projects

during the past year include elucidation of the chemical nature of antigen receptor on T-lymphocytes through the use of cross-reacting membranes and regulation of timing of cell division in marine diatoms. Both projects were done for MIT. For the VA Medical Center in Boston, the Center did patient sample screening to explore the relationship between T-lymphocyte sub-population percentages and the tendency to develop septic complications after surgery. And for Brown University and Rhode Island Hospital, the Center conducted screening of human tumor populations using propidium iodide as a DNA stain, to determine the relationship between cell cycle phase and sensitivity to a variety of conventional therapies.

PHILLIPS W. ROBBINS

Clinical Research Center

The Clinical Research Center (CRC) is an Institute resource established for the support and care of subjects participating in research studies conducted by MIT investigators and their collaborators. 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 3,212 inpatient days and 1,800 outpatient visits under 39 different research protocols. More than 70 scientific articles were published or accepted for publication as the result of work associated with the Center. Bed occupancy averaged 88 percent.

The CRC has continued under the direction of Nevin S. Scrimshaw, Ph.D., M.D., program director; William Dietz, M.D., Ph.D., assistant program director; and John N. Udall, M.D., Ph.D., assistant program director. Drs. Dietz and Udall received continuations of their two-year awards as clinical associate physicians at the CRC. Robert A. Hoerr, M.D., was appointed as assistant program director in July 1981. Cheryl M. Heilbrunn replaced Patricia Anderegg as administrator in July 1981.

MIT departments using the CRC include Nutrition and Food Science, Chemical Engineering, Mechanical Engineering, Biology, Psychology, and the Arteriosclerosis Center. The CRC's wide variety of research protocols and multiple observations per patient continue to place heavy demands on its specialized computing facility. A new PDP 11/44 computer has been purchased and installed to provide support for the CRC staff and investigators.

The Clinical Nutrition Training Program grant for physicians participating in the doctoral program of the Department of Nutrition and Food Science was renewed for five years by the National Institutes of Health (NIH). In collaboration with four area hospitals, CRC facilities were used by the fellows for many research protocols conducted under the supervision of faculty and senior investigators. During the past year, 23 physicians, qualified in the specialties of internal medicine, pediatrics, or surgery, 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 enter clinical departments of medical schools where they have been 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.

Several projects are representative of the wide variety of investigators utilizing the CRC. 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, Professor Young 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 major area of collaboration between CRC investigators has been the association between the neuroendocrine division of the Department of Nutrition and Food Science and the Department of Psychology. This collaboration has been a consequence of the convergence of the research interests of the two groups. Drs. John Growdon and Richard Wurtman (Nutrition) have continued their basic studies of the amino acid precursors of neurotransmitters. Likewise, Dr. Suzanne Corkin and her investigators (Psychology) have extended their studies of brain injury in World War II veterans and amnesics to patients with cingulotomies and craniopharyngiomas. Because the neuroendocrine division was interested in the effects of administration of neurotransmitter precursors in patients with conditions such as Alzheimer's disease, and because the Psychology Department had developed unique and highly specific tests to measure cognitive function amd memory, collaboration in several studies of Alzheimer's disease has resulted in a comprehensive approach to this disorder.

Biomedical developments in the basic science departments at MIT continue to find a base for preliminary human trials at the CRC. The most recent achievement in this area is the development by Dr. Padmakar Lele (Department of Mechanical Engineering) of a focused ultrasound device to generate hyperthermia. Preliminary studies of the application of focused hyperthermia to the treatment of cancer were done in the CRC, and an extension of these studies has been funded by NIH. Hyperthermia of tumors, in combination with radiation or chemotherapy, appears a promising technique for the treatment of cancer.

NEVIN SCRIMSHAW

George Russell Harrison Spectroscopy Laboratory

The George Russell 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, Chemical 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.

MIT Regional Laser Center

The Regional Laser Center, a National Science Foundation Regional Instrumentation facility housed in the Spectroscopy Laboratory, is now in its third 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. Professor Michael Feld, Department of Physics, is director of the Center; Professor Jeffrey Steinfeld, Department of Chemistry, is its scientific coordinator; and Dr. Ramachandra Dasari is project coordinator. Dr. Peter Pappas was appointed managing scientist of the Regional Laser Center and administrative officer of the Spectroscopy Laboratory during the past year.

Current available equipment includes continuous wave (CW) and pulsed dye lasers in the visible and near ultraviolet, CW and pulsed CO_2 lasers, a tunable diode laser spectrometer, and a laser Raman spectrometer. All are interfaced with microcomputers which control experiments and collect and analyze data. Auxiliary equipment includes a transient digitizer and an optical multichannel analyzer (OMA) with digital read-out. Up to the present, 47 projects have been initiated at

the Center in various disciplines, out of which 22 originated from MIT faculty and 25 from other academic institutions and industry. Scientists from Brazil, Argentina, China, India, Canada, and Israel are currently working at the Center. More than 30 publications have resulted so far from the work performed.

RESEARCH HIGHLIGHTS

Professor Alexander Rich and Drs. Andrew Wang, Gary Quigley, and Katsuhiko Fujii of the Department of Biology have continued their work on the three-dimensional structure and stability of nucleic acid molecules. They have solved the structure of deoxy octanucleotide, which was found to have the Z-DNA conformation, and concluded that the van der Waals attraction between the methyl groups on opposite strands is important for the stability of the molecule. The structure of another octanucleotide, which forms a right-handed fragment of DNA with a conformation having sequence dependent features, also has been solved. These conformational features may play an important role in the recognition of DNA by proteins.

Professors Richard Lord and Gregory Petsko and Drs. William Gilbert and Thomas Thamann of the Department of Chemistry have compared the structures of ribonuclease A in the crystalline state and in free solution. The effect of temperature on the folding of the protein was evaluated. Similar studies were also carried out on the effect of metal ions on the conformation of the polypeptide hormone calmodulin. The changes that take place when the protein is switched on by metal binding have been characterized.

Professor Petsko, in collaboration with Lawrence W. Ryan, Jr., of the Department of Chemistry and Dr. Xui-Bing Wei of Shanghai Medical College, China, have investigated the effect of laser treatment on tumor cell growth. It was found that ultraviolet laser irradiation at 334.7 nm kills implanted tumors in mice without destroying normal cells. This technique shows promise for treating rapidly growing cancers, particularly surface ones. The biochemical cause of this effect is under investigation.

Professor Mark Wrighton and Dr. William Smothers of the Department of Chemistry have initiated experiments to establish the structure of reactive excited states and intermediates from laser excitation of metal complexes. New results for excited $ClRe(CO)_3$(2,2'-bipyridine) are consistent with an excited state in which substantial Re -> 2,2'-bipyridine charge transfer occurs. The use of high-power lasers and the newly assembled OMA facility have made it possible to record extremely weak excited-state Raman signals.

Professor William Orme-Johnson and Dr. Mark Walters of the Department of Chemistry have recently recorded Raman data on the molybdenum-iron protein of the enzyme nitrogenase, yielding information on the protein's secondary structure. Resonance Raman experiments are being conducted to study the molybdenum-iron-sulphur chromophore, which is believed to be the binding site for the dinitrogen substrate.

Professor Robert Field and Drs. Keith Cross and Michael Dulick of the Department of Chemistry, and Professor Colan Linton of the University of New Brunswick, Canada, have been engaged in the high-resolution spectroscopy of diatomic molecules. Studies include Doppler-free spectroscopy of metastable CaO, fluorescence spectroscopy of PrO, CeO, and LaF, optical double resonance on Rydberg states of BaF, and direct observation of spin-forbidden transitions in MgO. An important result is that Ligand Field Theory provides global insights into the electronic structure of all rare earth chalcogenide and halide diatomic molecules and ions.

Professor James Kinsey and Dr. Carter Kittrell of the Department of Chemistry and Professor Field have completed stimulated emission pumping studies of highly excited vibrational levels of the acetylene ground electronic state. They also carried out two-photon spectroscopy of the CO $D\,^1\Delta - X\,^1\Sigma^+$ system, yielding information on the last remaining unknown valence state of CO. Professor Kinsey and Dr. Kittrell also have investigated the photodissociation products of ozone in the 266 nm wavelength region.

Professor Steinfeld and Dr. Zhu Qing-shi of the Salt Lake Institute of the Chinese Academy of Sciences have analyzed vibration-rotation spectra of the ν_2 and ν_5 fundamentals of CDF_3, and the ν_9 band of C_2H_5Cl, recorded by means of Fourier transform and tunable diode laser infrared

spectrometers. Vibrational and rotational constants were derived, some of which are two orders of magnitude better than those reported earlier. They also have discovered close coincidences between the CO_2 10R(16) laser line and two C_2H_5Cl transitions.

Professor Steinfeld and Dr. Martin Dubs of the Department of Chemistry have performed detailed spectroscopy and measured dipole moments of the $2\nu_3 \leftarrow \nu_3$ transition in SF_6 using high-resolution infrared double resonance techniques. Collisional rates measured in ground and excited vibrational states revealed no restriction on relaxation among fine structure levels.

Professor Feld and Drs. Dasari, Pappas, and John Thomas, all of the Spectroscopy Laboratory, and Dr. Zhu Xiwen, a visiting scientist from Wuhan Institute of Physics, China, continue their research on laser-induced nuclear orientation, in which laser optical pumping is used to orient nuclei of atoms in a vapor cell. To achieve complete Doppler coverage with a single mode laser, trace amounts of a rare gas buffer are used to induce velocity-changing collisions. An Li sample being prepared for a weak interaction parity non-conservation experiment has achieved a density of $10^{14}/cm^2$. Velocity-changing collision cross sections in Li and Na have been measured. An experiment to measure isomer shifts and nuclear moments in an isomeric state of the Rb nucleus by monitoring the anisotropy of the emitted gamma rays is also under way. Aspects of this work have been done in collaboration with Dr. Daniel Murnick of Bell Laboratories and Dr. Charles Holbrow, a visiting professor on sabbatical from Colgate University.

In the past year, Professor Feld and Drs. Thomas and Dasari have developed the concept for a new type of laser device, called a photon recycler, which directly converts heat into near millimeter wave radiation using infrared pump photons as a catalyst. The device, a type of heat engine, has some common features with an optically pumped laser and uses gas dynamic expansion to transport and cool vibrationally excited molecules. Candidate molecules under study are N_2O and CH_3Cl. Other related experiments in CH_3OH to study vibrational heating are in progress, using a high-resolution infrared double resonance spectrometer with a CO_2 laser pump and a tunable diode laser probe. Professor Vasant Itagi, a visiting scientist in the Spectroscopy Laboratory on leave from Marathwada University in India, has collaborated in this work.

Professor Feld, Dr. Thomas, and Luis Spinelli, a research engineer in the Spectroscopy Laboratory on leave from the Centro de Investigacines en Laseres y Aplicaciones in Buenos Aires, have developed a very sensitive velocity-selective photon echo spectrometer for studying collisional phenomenon in gases. The first experiments, in Yb with rare gas buffers, have measured phase disrupting, velocity changing, and total coherence-perturber collision cross sections. Preliminary results of the velocity dependence of the cross sections indicate that a van der Waals (C6) interaction is dominant in these systems.

MICHAEL S. FELD

Laboratory for Nuclear Science

The Laboratory for Nuclear Science (LNS) provides support for research by faculty and staff members primarily in the fields of basic nuclear and elementary particle physics, including the activities of the Center for Theoretical Physics. It also supports some projects involving application to other fields of experimental techniques developed in its primary activities. It provides a computing facility for its program. The primary experimental programs are in three areas: the largest effort is in intermediate-energy nuclear physics, centered at the Bates Linear Accelerator in Middleton, Massachusetts. The second area is high-energy physics, with major projects at Fermi National Accelerator Laboratory (FNAL) in Batavia, Illinois, at the Stanford Linear Accelerator Center (SLAC) in Palo Alto, California, 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 Oak Ridge National Laboratory (ORNL).

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 some 115 user physicists (89 domestic, 26 foreign) from 36 other universities and laboratories in the US, Canada, Japan, and Europe, are presently engaged as initiators or collaborators in experiments there. Twenty-five MIT graduate students were associated during the past year with the intermediate-energy nuclear physics program.

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 used intensively in 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. Work continues on a beam recirculation system which will increase the maximum beam energy to 750 MeV. The required building modifications and tunnel construction have been completed, and the higher energies will soon be available. Also being developed, in collaboration with Yale University physicists, is a polarized electron beam source, which will open a new area of experimental investigation.

Another group in intermediate-energy nuclear physics 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 1982, the Electromagnetic Interactions (EMI) 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 2×10^{-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 in 1983.

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 obtained over one million bubble chamber pictures in 1982. They are also collaborating on the development of a new type of bubble chamber and a holographic photography system to be used at the 1,000 GeV Tevatron being constructed at FNAL in the search for a new type of neutrino associated with the tau lepton.

The Counter Spark Chamber (CSC) group, in a collaborative effort, has constructed a major new detector for high-energy neutrinos at FNAL. The initial experimental program for 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 contains 350 tons of instrumented material in addition to a large muon spectrometer) were successfully tested in 1981. The detector was completed in 1982, and an experimental run was carried out to study the nucleon structure functions associated with the neutral weak current. This detector will be used for a continuation of these studies when the FNAL Tevatron comes into operation.

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 constructed and commissioned 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 groups 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 Department of Biology, has developed an X-ray diffraction facility for protein crystallography based on a wire drift chamber detector originally developed at the European Center for Nuclear Research (CERN). Initial crystallographic studies 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 intereact with one another through gauge fields. There is currently a gauge field theory of the strong interactions called "quantum chromodynamics" or QCD and another, the Weinberg-Salam-Glashow theory, that unifies the electromagnetic and weak interactions. Both of these theories, which agree with experiments insofar as they have been tested, and with gauge theories in general, are being investigated by the particle theorists. Studies are also being made of "grand unified theories" which attempt to unify weak, electromagnetic, and strong interaction gauge theories.

The Particle Theory group has studied, on the one hand, the nearly 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 phenomenological models: the parton model and the MIT bag model, respectively, which are thought to be approximations to QCD.

Some of the QCD-related topics studied during the past year are the following: a model of the QCD vacuum including a gluon condensate and its spectrum; a complete analysis of non-perturbative corrections to the parton model; and the phase structure and confinement aspects of gauge theories. Work on grand unification models has led to a new theory of cosmogenesis and to detailed calculations of phenomena which occurred at the very early stages of the universe. In the area of the theory of electromagnetic 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.

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. The role of nucleon internal degrees of freedom in nuclear structure and dynamics has been a central theme.

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, many of them based on the mean field functional integral approach, 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. The latter studies include both phenomenological approaches utilizing hadron and quark degrees of freedom at long and short ranges, respectively, and microscopic calculations of scattering phenomena with confined composite systems.

Meson-nucleus interactions are being studied in terms of isobar-nucleon hole collective doorway states, with a complex isobar-nucleus interaction potential playing a central role. The microscopic basis of the model has been elucidated, and associated predictions have been tested against data.

A continuing program of interrelating semi-leptonic weak and electromagnetic interactions in nuclear phenomena is being pursued.

Summary of Support

Participants in the various research programs during the past year included approximately 460 people. This includes 50 academic staff members, 87 graduate students, and at least 77 undergraduates from MIT and other institutions. The latter were involved in senior theses, Undergraduate Research Opportunities Programs, work-study, and similar programs. There were 82 research staff members with Ph.D.s, including visitors and guests, and 160 employees in supporting categories such as engineers, technicians, machinists, computing, and administrative personnel. Over 115 active user physicists from some 36 institutions excluding MIT participated in the program at the Bates Linear Accelerator. At least 13 Ph.D.s, two S.M.s and 10 S.B.s were awarded based on thesis research within LNS.

Support during fiscal year 1982 from the contract with the US Department of Energy (DOE) is expected to total $14,213,000. This represents an increase of about two percent over the preceding year. This sum breaks down as follows: operations costs (salaries, wages, materials, services, travel, and overhead) were $11,713,000 -- of which $3,993,000 was for experimental and theoretical high-energy physics, $6,080,000 for intermediate nuclear energy physics for the support of the Bates Linac facility and program, and $1,640,000 for nuclear structure theory, solar neutrino, and heavy-ion experiments. Equipment costs totaled $2,400,000 -- of which $900,000 was for high-energy physics and $1,500,000 was for medium-energy and heavy-ion physics. A total of $100,000 will be expended for general plant projects associated with the Bates Linear Accelerator. Support for relatively new Laboratory programs relating to the application of high-energy techniques to medical and biological problems totaled some $140,000 (primarily from the National Institutes of Health). Support for other programs within LNS, including support from other institutions and laboratories for collaborative work undertaken directly by LNS, is expected to total about $40,000.

JEROME I. FRIEDMAN

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, Arizona. The most important event since the founding of the Observatory occurred in April

of this year. The National Science Foundation agreed to provide matching funds for the expansion of the present facilities through the construction of a 2.4 m telescope. Work on the primary mirror is well under way at Norman Cole's optical shop in Tucson, and the engineering design of the telescope is in progress at DFM Engineering in Boulder, Colorado. The telescope is scheduled to be in operation early in 1985. It will provide the staff and students at the three institutions with a first-class instrument that will be used at the frontier of astronomical research into the 21st century. MIT observers will be entitled to one-third of the available time on both the 2.4 m and 1.3 m telescopes, a total of about 240 nights per year.

Dr. George R. Ricker and his collaborators have developed a focal-plane instrument which uses CCD detectors and operates both as a faint object spectrometer and a direct imaging camera. The instrument was used by many MIT observers during three extended observing runs in March 1981, October/November 1981, and June 1982. During the 1981-82 academic year, a total of 18 MIT faculty members, staff members, and graduate students made observations at the McGraw-Hill Observatory.

The past year's research includes the following: Professor Claude R. Canizares and Dr. Gerard A. Kriss have continued their program of optical identification of quasars and active galaxies initially located through X-ray observations with the Einstein Observatory. From a total of 94 X-ray error circles, a sample of 45 such objects have been identified. In a search for pre-main sequence stars with weak emission lines, Dr. Eric D. Feigelson and Dr. Kriss obtained spectra of all stars brighter than 12th magnitude in the vicinity of four dark clouds.

Dr. Jeffrey E. McClintock, Dr. Larry D. Petro, and Ronald Remillard discovered light variations in the 19th magnitude X-ray nova A0620-00, which provides the first evidence for a short orbital period in that system. In another program, they obtained high-resolution spectra of 140 stars which will be used with other data to determine the distances to the galactic X-ray sources Scorpius X-1 and Cygnus X-2. With Professor Hale V.D. Bradt and Dr. Rodger E. Doxsey, they discovered six new candidates for the optical counterparts of X-ray sources, and concluded a detailed study of H0323+02 which they identified optically last year.

In an ongoing program, Dr. Robert G. Hohlfeld, in collaboration with Dr. William P. Blair of the Center for Astrophysics, obtained many new spectrophotometric observations of the remarkable galactic object SS433 which contains a precessing jet. These data will be used to test models of astrophysical jets which are being constructed by Dr. Hohlfeld.

Dr. Marshall W. Bautz used the CCD camera to study galaxies which are members of X-ray luminous clusters. Dr. Steven Meyer detected hydrogen Paschen lines in several Seyfert galaxies which should lead to a better understanding of the geometry and conditions in the line-emitting regions. Bradley Schaefer searched for the optical counterpart of the 19 November 1978 gamma-ray burst source with CCD camera to a limit of 25th magnitude. Professor Edward L. Wright and Charles Lawrence continued their search for the optical counterparts of 700 radio sources discovered with the VLA in the MIT 5 GHz survey. One hundred fields have been observed with the CCD camera. Dr. Ricker discovered six candidates for the optical counterparts of a peculiar class of "optically quiet," X-ray emitting, flat-spectrum radio QSOs.

CLAUDE R. CANIZARES

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.

This past year a variety of observing programs were carried out with the new CCD camera and spectrograph (MASCOT) and the 24-inch telescope. Dr. Edward Dunham, Richard Baron, and Greg Aldering, Class of 1983, obtained photometry of stars to be occulted by Uranus during

1983-84, and made observations aimed at determining the rotation periods of comets. Dr. Dunham also began observing Saturn's moon Hyperion in order to determine its rotation period, which is needed for proper interpretation of the Voyager 2 images of Hyperion. Mr. Baron and Ricky Morgan, Class of 1982, found a substantial improvement in the quality of stellar images when air was rapidly exhausted from the dome. Sam Conner, Class of 1982, recovered several faint asteroids and discovered a new one. Unfortunately, he was not able to follow up this discovery by obtaining an orbit for the asteroid.

Further observations of lunar occultations of the Praesepe cluster were obtained, as part of our ongoing program to determine stellar masses and distances to binary systems. This work also involved some experimenting with the dual telescope method of deriving slopes of the lunar limb.

The student projects for the course in observational astronomy (12.117J-8.287J), taught last year by Dr. Dunham, included multicolor photometry of the M39 cluster, patrol plates of BL Lac objects, development of a new procedure for sensitizing IIIaF plates, and astrometric observations of several asteroids.

During IAP, members of the MIT community attended the Observatory's open night, and several students participated in the astrophotography program led by Dr. Dunham.

Students from Professor James Elliot's astronomy course (12.113) visited the Observatory during the fall term, and 40 students in the new observing seminar (12S23) made extensive use of the Observatory during the spring term. Professor Janes of Boston University and his observational astronomy class used the 16-inch telescope over a period of a week for photometric observations. Senior theses for the Department of Physics, based on observations at Wallace Observatory, were completed by Sam Conner and Ricky Morgan (both in the Class of 1982), 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, the Division of Comparative Medicine, and 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. For purposes of ready comparison with information presented in our previous reports, we present these data in formats similar to those used in past years. The data generally indicate a continuation of trends which have been characteristic of recent years. That is: patterns of modest growth in enrollments continue, hence numbers of degrees awarded continue to grow despite significant "softening" in financial support.

In response to concerns expressed at several levels of the Institute, including discussions within the Corporation, this year the Graduate School completed an extensive 10-year review which included studies of graduate admissions, enrollments, degree patterns, financial support structures, and minority, female, and foreign representations. Each department provided interpretations of these trends as well as commentary concerning applicant quality, future prospects, and problems for departmental graduate programs.

For the most part, observations concerning quality of the applicant pools were positive and encouraging. Some departments indicated a "saturation" level had been achieved in terms of the faculty's ability to supervise adequately the numbers of graduates. These departments described plans for stabilizing or cutting back enrollments slightly. As is typical of all United States engineering graduate education, our engineering departments expressed significant concern with the continued decline in numbers of US citizens interested in continuing from master's to doctoral degree programs. Finally, essentially all departments expressed great concern about the increasing inadequacy of resources to provide financial support, particularly in light of the Institute's high tuition levels and the high cost of living in the Boston-Cambridge area.

Although there had been some indication, during the discussions which precipitated our undertaking this major review, that the reimposition of some form of institutionally imposed limits on admissions and enrollments (the old "quota system") might be used, this approach was rejected during the review of the report. Generally, there was a reaffirmation of the importance of maintaining responsibility for such decisions at the departmental level. Given the broad spectrum of philosophies which exist among the many disciplines which govern specification and evaluation of credentials, course requirements, performance evaluation, and financial support, the continuation of departmental self-regulation appears to be the wisest course to follow. In so doing, we must and will continue to make information available to departmental faculties concerning such matters as housing availability, trends in Federal support, changes in immigration laws, etc., to assist them in formulating decisions about graduate enrollment.

Problems created by declining financial support seemed to pervade essentially all discussions of graduate education taking place at MIT and in various national organizations. Inspection of Tables IV, V, and VI quickly reveals a further erosion of Federal fellowship and trainee support at the Institute although an encouraging upturn in industrial fellowship support is apparent. Many "enlightened" industrial organizations are signaling their concern for the national importance of advanced graduate training by providing additional scholarship and fellowship support -- largely in engineering and, to a lesser extent, in science. Little or no such support appears forthcoming, however, in the social sciences, and in architecture and planning -- the traditionally "poor" departments.

Students in these latter disciplines as well as in the Sloan School have become increasingly dependent upon loan programs to eke out tuition and living expenses. Over the past few years the Federal Guaranteed Student Loan Program and the College Work-Study Program have emerged as major resources for these disciplines at MIT (and for a great number of students in graduate programs in arts and sciences at more traditional universities).

The impact on graduate support cutbacks in the Federally supported student aid programs, proposed by the current administration at the beginning of the Federal budget discussions this year, proved to be a *cause celebre* which brought together the several heretofore "many-voiced" graduate educational communities whose efforts were, at best, poorly coordinated. The reaction of affected segments of the voting population was not unlike the reaction to the administration's earlier proposals to cut back on Social Security. Our own Graduate Student Council undertook a number of initiatives, including a lobbying trip to Washington. Several students, together with their counterparts from across the nation, managed to gain the attention of senators and representatives in a grass-roots effort, the results of which will probably prove more telling than those of faculty, administrators, and the several Washington educational organizations. At the very least, many in Congress now talk about graduate education separately from undergraduate education. Indeed, at this writing, access by graduate students to the Guaranteed Student Loan Program for the next academic year or two now seems assured.

As important as fellowship and loan support is, the data in Tables IV, V, and VI also make evident that assistantship support is of paramount importance to our overall support program, particularly in the Schools of Science and Engineering. The educational importance of teaching assistantships and research assistantships is widely felt among faculty at MIT. With respect to the TA, one often hears the observation, "There's no better motivation to learn the subject than to have to teach it to a group of bright MIT undergraduates." Similarly, with respect to the RA, faculty regard this form of internship or partnership as a most effective vehicle to enhance professional competence. Indeed, during the formative days of development of the Federal role in sponsoring research at universities following World War II, it was widely understood by both the staffs of the sponsoring agencies and the faculties of the universities that manpower development through the involvement of graduate students in sponsored research was an important objective of the joint effort.

Unfortunately, the pressures on academic budgets have forced cutbacks in the number of graduate students supported as teaching assistants. Similarly, pressures to maximize research productivity in the short term and to compete successfully for sponsored research against less expensive institutions have resulted in a reduction in availability of research assistant positions. Some principal investigators are deploying funds which might formerly have supported research assistants to support more experienced full-time postdoctoral research staff. This trend is particularly noticeable in the School of Science.

In an effort to counter this trend and to increase our competitive position -- and thus secure more funds to support research assistants -- we are currently engaged in exploring new charging mechanisms which have the potential to reduce significantly the effective cost of research assistants to research projects. Unfortunately, I do not see a promising solution to the decline in support for teaching assistants.

We continue to make strong efforts to identify and attract foundation and industrial support with some modest success. We also continue to argue at the Federal level for the importance of graduate education (and hence graduate financial support) to the nation's long term well-being.

A few years ago the Institute was a prime mover in broadening the perspectives of the Consortium on Financing Higher Education (COFHE) to include graduate programs, and data from COFHE'S study on graduate education are now becoming available. It is clear that this information will be of great importance to the Congressionally sponsored National Commission on Student Financial Assistance. We also are taking strong initiatives in the development of Federal policy through our participation in the Association of Graduate Schools of the Association of American Universities.

I commented earlier on trends in the awarding of doctoral degrees to international students in engineering. I will not elaborate upon these comments because significant national attention has been paid to this "engineering school dilemma." I do believe, however, that it is important to mention briefly other matters of national concern regarding international students. Enrollment of foreign nationals in post-secondary US education has been increasing exponentially over the past decade or so. Currently there are approximately 300,000 such students, and projections

indicate that this number could reach 1,000,000 during the middle to latter part of the next decade. Thus, whereas the international student fraction of total enrollments at most institutions was very small until recently, this is now becoming of some significance. Consequently, new questions of institutional policy must be addressed -- not to mention the imperative need to clarify the Federal policies and procedures governing such matters as immigration status, work permits, and access to "sensitive" areas of teaching and research.

MIT has traditionally hosted relatively larger fractions of international students than most universities. The overall average percentage in the graduate population has hovered around 30 percent for some time, although the fractions in some engineering departments are significantly higher. Generally, we are somewhat better prepared than many universities in dealing with issues relating to our large and diverse foreign population -- English language competence, cultural adjustments, housing problems, health care, financial matters, dependents' problems, etc. Nevertheless, it has become clear over the past few years that we need to coordinate better the several offices which serve both our international students and other foreign constituencies (e.g., postdoctoral guests or employees). Thus, the Provost has recently asked Dr. Louis Menand of his staff to coordinate these efforts in a low-key manner as well as to maintain a more vigilant monitoring of developments in Federal policy which could bear upon our foreign populations.

All the issues I have touched upon have received considerable attention during the year from the Committee on Graduate School Policy (CGSP). In addition, that committee has discussed and supported further efforts to improve 1) information sent to incoming graduate students, 2) cancellation studies of graduate admissions, 3) health insurance coverage to dependents of foreign students, 4) identification of students from Mainland (PRC) and Taiwan, China, 5) programs in testing and teaching English as a second language, and 6) due process policies and procedures for graduate students.

I and my colleagues in the Graduate School acknowledge with sincere thanks the assistance of five faculty members who completed their terms this year as departmental representatives to the CGSP, and we welcome their replacements:

Materials Science and Engineering
  Professor Regis M.N. Pelloux to Professor Robert W. Balluffi
Urban Studies and Planning
  Professor Gary A. Hack to Professor Karen R. Polenske
Earth and Planetary Sciences
  Professor Charles C. Counselman,III, to Professor Gordon H. Pettengill
Sloan School of Management
  Professor Edward H. Bowman to Professor Gordon M. Kaufman
Nutrition and Food Science
  Professor Anthony J. Sinskey to Professor Steven R. Tannenbaum
Mathematics
  Professor Steven Kleiman to Professor Nesmith C. Ankeny

On a closing note -- as is evident from this brief account and the reports of my Graduate School colleagues which follow -- we find ourselves immersed in a diverse set of issues, many of which seem to be with us perennially; some are predictable new ones, and some are unforeseen new ones. Because we are so caught up, I fear we sometimes lose sight of our overall objectives. When I sense I may be losing perspective, I have only to engage in some conversations with one or more of my counterparts at other institutions to regain that perspective. We may be sailing in very difficult and treacherous waters, but ours, thank goodness, is a millpond compared to many graduate schools.

KENNETH R. WADLEIGH

GRADUATE WOMEN

Unfortunately, we have not seen further growth in the proportion of women in the graduate body although the numbers have grown. We have barely maintained a status quo with respect to percentages of enrollment and degrees awarded to women graduate students.

As the data in Table VII illustrates, the percentage of women in the fall of 1981 (18 percent) is identical to that for fall of 1980, although the number rose from 779 to 828, or 6.3 percent. The number of women in science and engineering increased from 444 in 1980 to 481 in 1981, an increase of 8 percent which is equal to the increase of national enrollments of women in science and engineering.

Our 6.3 percent increase in total enrollment of women can be compared with the Council of Graduate Schools/Graduate Record Examination Survey of Graduate School Enrollment. Data in that survey from Ph.D.-granting institutions showed an increase which was only 1.6 percent.

Perhaps another issue to contemplate is suggested by the first-year graduate enrollment. Many observers are concerned that the combination of escalating costs of graduate education coupled with threats of more and more cutbacks at the Federal level for support of higher education, in research, fellowship, and loan programs, can only result in a trend for post-baccaulaureate men and women to accept high-paying industrial positions, especially in engineering and science. Could the 2 percent decrease nationally in first-year graduate student enrollment be a first indication of such a trend? Could our own numbers that is, a 2.7 percent decrease in first-year enrollment, result from these forces? Of more concern may be the fact that a further breakdown indicates that women enrolling as first-year graduate students at MIT decreased by 4.3 percent, from 254 in the fall of 1980 to 243 in the fall of 1981, although maintaining a 19 percent portion of MIT's total first-year graduate population (Table VIII).

Numbers of applications to private doctoral institutions nationally increased 3.5 percent while those to MIT increased 2 percent. Overall, MIT's women applicants increased less than 1 percent while male applicants increased 2.8 percent (Table IX), but the School of Engineering applications from women increased 20 percent (this is, however, a small number of individuals: only 52).

The Sloan School of Management, not surprisingly, also attracted more applicants -- 5 percent more women and 2 percent more men.

Conversely, 6 percent fewer women applied to departments in the School of Science and 16 percent fewer women to departments in the School of Architecture and Planning.

An interesting but seemingly anomalous increase in applicants (+13 percent women and +9 percent men) to the School of Humanities and Social Sciences is puzzling, although the total enrollment in this School also increased slightly by 4 percent from 1980 to 1981.

The proportion of degrees awarded to women remained constant at 17 percent from 1980 to 1981, as shown in Tables X and XI. However, the gains realized in the number of doctoral degrees earned by women in 1980 were completely reversed in 1981. The earlier all-time high of 65 such degrees was reduced to only 49. The number of doctorates awarded to men increased 6 percent from 1980 to 1981.

The number of master's degrees awarded to women continued its annual increase, from 184 to 214, up 16 percent, but women still earned only 19 percent of the total master's degrees as compared to 18 percent last year.

Comparing MIT's totals to national statistics we find that a 2.2 percent increase in master's degrees awarded by private institutions is much smaller than MIT's 9 percent increase. At the doctoral level, MIT degrees increased by almost 2 percent compared to a 1 percent increase nationally at private institutions.

The financial support situation for women graduate students continues to be disproportionately affected, since the largest proportion of women still tends to enroll in those programs at MIT where financial resources are most limited. Our situation is similar to that at the national level, where surveys have indicated that the proportion of women relying primarily on self-support was higher than that of men in every field except the physical sciences.

At MIT, women must compete with male graduate students for available department research and fellowship funds. However, the Graduate School Office conducted its ninth annual competition for the Ida M. Green Fellowships for women entering graduate programs at MIT. The six women selected for these awards bring the total to over 50 women supported by these funds since the

inception of the program in 1974. In addition, about 10 outstanding women have been designated Honorary Ida M. Green Fellows, having won financial support from other national fellowship competitions. 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 International Business Machines Corporation and Xerox Special Opportunity Fellowship Programs 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, 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.

As competition for more limited financial resources becomes keener, we must continue to encourage women to pursue graduate studies in science and engineering by making such financial resources available to them.

JEANNE E. RICHARD

MINORITY GRADUATE STUDENTS

A sagging economy and its negative impact on graduate student financial aid for students in the social sciences and humanities contributed heavily to the decline in total minority graduate student enrollment at MIT for 1981-82. This is especially distressing in light of the increase of majority graduate student enrollment of 2 percent from last year. Minority graduate student enrollment decreased 18 percent from last year's enrollment, moving downward from 171 students in 1980 to 140 in 1981 (see Tables XII and XIII). This decrease follows a national trend of declining numbers for minority students in graduate schools across the country. It appears that the incentive for minority students to go on to graduate school, rather than to take a job in industry or business, is removed when fellowship money for graduate study is reduced or eliminated. As long as there are insufficient funds to support minority students in pursuing their studies beyond the baccalaureate level, I believe we will continue to see a negative slope in minority graduate student enrollment at the national level.

Enrollments in the School of Engineering and the School of Science have remained rather stable over the past three years, while those in the three "small" Schools (Architecture and Planning, Management, Humanities and Social Sciences) have declined. The level of enrollment in the social sciences for minorities is clearly dependent on the level of financial support offered. We have been able to attract a small number of minority graduate students with the Graduate School Office's "special graduate tuition awards," but the social science departments have not been able to add any money to these awards for living expenses. As a result of these financial limitations, we have lost several minority students whom we had admitted. Table XIV illustrates the yield in these three "small" Schools which had declining enrollments, and the yield in Science and Engineering where financial support is somewhat less stringent.

The data in Table XIV shows that those departments which can offer full fellowship support experience higher yield rates than do those departments which can offer only tuition grants or less. If we are to turn around this downward trend in minority enrollment, the Federal government, foundations, businesses, and other research enterprises must take a stronger role in assisting minority students in the social sciences and humanities with fellowships and research grants.

While we are disappointed with the low number of minority students that eventually enrolled in MIT's Graduate School, we continue to spread the word about MIT and opportunities for graduate study to as many persons as we possibly can. The Graduate School Office works very closely with the 23 academic departments in assisting them to attract and retain minority graduate students. Recruitment efforts in the past have centered on traveling to black colleges and other undergraduate institutions with large pockets of minority students; subscribing to the 3,000-plus names of

Educational Testing Service's Minority Locater Service and the Consortium for Graduate Degrees for Minorities in Engineering, Inc.; cosponsoring the Lincoln Laboratory Summer Program for Scientists and Engineers; participating in the National Names Exchange Program, where we -- along with 21 other prestigious graduate schools -- exchange names and addresses of our top minority juniors and seniors; inviting some of our top minority prospects to campus; and writing letters to faculty, administrators, and alumni around the country to help identify promising minority scholars. We will continue to recruit minority graduate students to MIT as strongly as we have in the past while realizing that it will take a Herculean effort just to remain where we were last year.

Minority graduate students are graduating from MIT with master's, engineer's, and doctoral degrees in their chosen fields. MIT is not a "revolving door," where students leave as quickly as they enter without earning a degree. Over the past 10 years minority students have entered departments with no previous minority graduate students, and they have gone on to graduate with distinction. In the past there were only a handful of black alumni from MIT, but there are now enough black graduates to form a national black alumni association of MIT. Our graduates have gone on to take teaching positions at some of our better colleges and universities (including our own faculty here at MIT) as well as to become research scientists at large research laboratories; business managers in large corporate bodies; architects and planners in city, state, and Federal governments; and respected leaders in communities all over the country.

During the past academic year (1981-82), minority graduate students received a total of 51 master's and doctoral degrees from MIT. We have come a long way from the days of one or two minority graduates. This is especially significant when compared to our total enrollment of only 16 minority students in the graduate school in 1968. We are now graduating over three times that enrollment figure! We have worked hard to increase the minority presence at MIT and we are beginning to see the fruits of our labor. If we are to continue to be successful in this extremely important area of equal access, we must marshal all the available resources (ideas, energy, sensitivity, and money) that we have at our disposal to keep the momentum from dying out and deferring the dream.

JOHN B. TURNER

For simple comparison with data for 1980-81, the following statistical information for 1981-82 is presented in the same format. Numbers in parentheses indicate the change from 1980-81 to 1981-82.

TABLE I

REGULAR GRADUATE STUDENT ENROLLMENT, FALL TERM 1981

	Foreign(1)	Women(2)	Minority(3)	Total	Non-Residents(4)
School of Architecture and Planning	119(+23)	157(+ 4)	41(-20)	427(+37)	38(+10)
School of Engineering	724(- 5)	230(+17)	55(+ 1)	2157(+69)	1(- 3)
School of Humanities and Social Science	94(+ 7)	96(+ 5)	9(- 8)	368(+15)	47(- 4)
Sloan School of Management	120(+19)	90(0)	10(- 4)	448(+29)	6(+ 1)
School of Science	284(+18)	251(+20)	25(- 3)	1124(+ 2)	14(+ 6)
Health Sciences and Technology	6(+ 2)	4(+ 3)	0	17(+ 5)	0
TOTAL	1347(+64)	828(+49)	140(-34)	4541(+157)	106(+10)

(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

Advanced Degrees Conferred	M.C.P., M. Arch., M. Arch. A.S.	S.M.	Engineer	Sc.D.	Ph.D.	Total
September 1981	13(- 6)	163(0)	10(+ 4)	13(+ 1)	85(+ 1)	287(- 1)
Woods Hole			0(0)	1(+ 1)	2(- 2)	
February 1982	16(+ 5)	246(+25)	15(-10)	18(+ 1)	117(+ 2)	416(+21)
Woods Hole			1(+ 1)	0(- 1)	3(- 2)	
June 1982	68(+16)	612(+65)	37(- 3)	27(+10)	132(- 9)	882(+84)
Woods Hole			1(0)	0(0)	5(+ 5)	
TOTAL	97(+15)	1021(+90)	64(- 8)	59(+12)	344(- 5)	1585(+104)

Numbers in parentheses indicate change from 1980-81.

TABLE III

DOCTORAL DEGREES AWARDED EACH YEAR BY SCHOOL AND CITIZENSHIP

Each number is the total of the doctoral 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.

Academic Year		Arch.	Eng'g	Hum. & Soc. Sci.	Sloan	Science	Total
1972-73	Citizen	4 (.022)	112 (.107)	34 (.160)	4 (.017)	122 (.169)	276 (.115)
	Foreign	1 (.020)	54 (.114)	17 (.274)	3 (.024)	45 (.208)	120 (.129)
	Total	5	166	51	7	167	396
1973-74	Citizen	6 (.034)	93 (.088)	29 (.136)	5 (.021)	129 (.179)	262 (.109)
	Foreign	1 (.016)	49 (.099)	18 (.273)	6 (.052)	42 (.196)	116 (.122)
	Total	7	142	47	11	171	378
1974-75	Citizen	7 (.037)	104 (.095)	31 (.143)	10 (.040)	110 (.146)	262 (.105)
	Foreign	2 (.033)	56 (.107)	10 (.154)	8 (.080)	24 (.110)	100 (.103)
	Total	9	160	41	18	134	362
1975-76	Citizen	1 (.005)	83 (.073)	49 (.232)	12 (.055)	126 (.162)	271 (.106)
	Foreign	1 (.019)	67 (.114)	7 (.119)	2 (.017)	42 (.180)	119 (.113)
	Total	2	150	56	14	168	390
1976-77	Citizen	6 (.026)	79 (.068)	33 (.155)	2 (.007)	125 (.156)	245 (.090)
	Foreign	4 (.071)	64 (.106)	19 (.264)	1 (.010)	46 (.199)	134 (.126)
	Total	10	143	52	3	171	379
1977-78	Citizen	5 (.023)	111 (.096)	50 (.240)	8 (.029)	119 (.146)	293 (.110)
	Foreign	3 (.039)	66 (.103)	13 (.169)	15 (.139)	35 (.141)	132 (.115)
	Total	8	177	63	23	154	425
1978-79	Citizen	10 (.041)	80 (.066)	35 (.164)	10 (.035)	126 (.151)	261 (.093)
	Foreign	3 (.033)	64 (.101)	11 (.130)	9 (.088)	33 (.142)	120 (.105)
	Total	13	144	46	19	159	381
1979-80	Citizen	8 (.031)	96 (.074)	40 (.156)	5 (.017)	127 (.153)	276 (.094)
	Foreign	3 (.034)	66 (.096)	11 (.109)	3 (.029)	28 (.115)	111 (.091)
	Total	11	162	51	8	155	387
1980-81	Citizen	12 (.044)	88 (.065)	40 (.178)	7 (.022)	118 (.138)	265 (.088)
	Foreign	7 (.078)	75 (.103)	12 (.153)	2 (.020)	35 (.130)	131 (.104)
	Total	19	163	52	9	153	396
1981-82	Citizen	7 (.023)	94 (.066)	35 (.128)	4 (.012)	124 (.148)	264 (.083)
	Foreign	2 (.017)	75 (.104)	21 (.223)	6 (.050)	35 (.123)	139 (.103)
	Total	9	169	56	10	159	403

TABLE IV

A "SNAPSHOT" OF GRADUATE STUDENT SUPPORT "FULL AWARDS"

The following sources provided at least full tuition support for graduate students during the fall term 1981. Total regular graduate student enrollment, not including non-residents, was 4,435.

	Numbers of Students	Percent Total Enrollment	Change in Numbers of Students from 1980-81
FELLOWSHIPS AND TRAINEESHIPS AWARDED BY MIT			
NIH and NIMH Traineeships	110		- 3
DOE Fellowships	0		- 6
HEW Domestic Mining and Mineral Fuel Traineeships	7		- 6
HEW Graduate and Professional Opportunities Program Fellowships	6		- 8
MIT Endowed and Other Fund Fellowships	188		-18
Industrial and Foundation Fellowships	179		+40
	490	11%	+ 1
FELLOWSHIPS AWARDED BY SPONSORS TO MIT STUDENTS			
NSF Graduate Fellowships	147		+ 3
NIMH Fellowships	1		- 1
Hertz Fellowships	35		- 6
	183	4%	- 4
STUDENT ASSISTANTSHIPS			
Research Assistants	1455		+ 6
Teaching Assistants	391		-28
Instructor-G	8		- 8
	1854	42%	-30
SPONSORED STUDENTS			
Many students receive support from employers and sponsors. The following reflect Student Accounts billings for tuition to employers and sponsors who presumably provide stipends to students by private arrangements:			
US Army, Air Force, Coast Guard	27		- 6
US Navy and Related Programs	53		+11
Foreign Countries and International Programs	253		-20
Industry and Foundation (US)	129		+ 6
	462	10%	- 9
SUMMARY BY SOURCES - FULL AWARDS			
Federal Fellowships and Traineeships	271	6%	-21
Graduate Student Staff	1854	42%	-30
Industrial and Foundation Awards	214	5%	+34
MIT Endowed and Budgeted Funds	188	4%	-18
Students Sponsored by External Sources	462	10%	- 9
	2989	67%	-44

TABLE V

DISTRIBUTION OF FUNDING FOR GRADUATE STUDENT TUITION AND LIVING EXPENSES

FALL TERM 1981

Estimates of Required Funding

Tuition	$15,908,412
Stipend ($700/mo. for 4-1/2 months)	13,480,600
Total Estimated Required Funding	$29,389,012

Identified Support by Category		Percentage of Total	Equivalent Percentage for Fall Term 1980
Research Assistantships	$ 9,199,860	31.3	33.5
Teaching Assistantships & Inst. G.	3,212,558	11.0	11.8
Federal Fellowships and Traineeships	1,646,294	5.5	6.5
General and Endowed Support (Departmentally controlled)	1,158,962	4.0	3.5
General and Endowed Support (Graduate School Office controlled)	383,508	1.3	1.9
Outside Sources Administered by Departments	974,978	3.0	3.0
Outside Sources Administered by Graduate School Office	555,222	1.9	1.6
Outside Sources, Direct Billing to Sponsor by Institute, Tuition Only	1,291,541	4.4	4.5
Total Identified Support	$18,422,923	62.4	66.3
Loans	2,535,948	8.5	8.0
College Work-Study	308,223	1.0	1.9

TABLE VI

TRENDS IN GRADUATE STUDENT SUPPORT
($000's)

	Fellowships Traineeships Scholarships*	Staff Tuition Awards (TA & IG)	Staff Salaries (RA & TA)	Loans: MIT Only	Loans: Including Outside Agencies
1969-70	5,197 (.712)	1,056 (.145)	6,815 (.934)	470 (.064)	643 (.088)
1970-71	5,396 (.655)	1,182 (.143)	6,850 (.831)	483 (.059)	672 (.082)
1971-72	5,076 (.589)	1.294 (.150)	7,086 (.823)	696 (.080)	827 (.096)
1972-73	4,687 (.486)	1,432 (.150)	7,991 (.828)	754 (.078)	916 (.095)
1973-74	3,930 (.378)	1,453 (.140)	8,781 (.844)	852 (.082)	1,014 (.097)
1974-75	3,693 (.318)	1,738 (.150)	9,760 (.840)	1,075 (.093)	1,293 (.111)
1975-76	3,447 (.259)	1,878 (.141)	10,878 (.816)	1,141 (.086)	1,407 (.106)
1976-77	3,454 (.229)	2,065 (.137)	11,654 (.722)	1,419 (.094)	2,013 (.133)
1977-78	3,418 (.205)	1,978 (.118)	12,479 (.750)	1,391 (.084)	2,201 (.132)
1978-79	3,667 (.198)	2,355 (.127)	15,251 (.823)	962 (.052)	2,387 (.129)
1979-80	3,733 (.172)	3,079 (.142)	16,610 (.766)	976 (.045)	3,575 (.165)
1980-81	3,970 (.149)	2,821 (.106)	18,650 (.702)	434 (.016)	4,434 (.167)
1981-82	4,194 (.128)	2,799 (.085)	21,258 (.648)	662 (.020)	5,412 (.165)

* 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 VII

WOMEN GRADUATE STUDENT ENROLLMENT

Comparison of Fall Term Enrollments - 1980 and 1981

	Number of Women		% of Women in Total Enrollment	
	1980	1981	1980	1981
School of Architecture & Planning				
Architecture IV	71	77	35%	31%
Urban Studies and Planning XI	82	80	44%	45%
	153	157	39%	37%
School of Engineering				
Aeronautics and Astronautics XVI	12	10	7%	6%
Chemical Engineering X	34	36	17%	16%
Civil Engineering I	37	31	13%	12.5%
Electrical Engineering and Computer Science VI, VI-A, VI-W	47	56	8%	10%
Materials Science III, III-B, III-W	33	40	16%	17%
Mechanical Engineering II, II-T, II-W	36	35	10%	9%
Nuclear Engineering XXII	10	13	6%	8%
Ocean Engineering XIII, XIII-A, XIII-B, XIII-W	4	9	2.5%	5%
	213	230	10%	10.6%
School of Humanities and Social Science				
Economics XIV	17	22	14%	17%
Linguistics and Philosophy XXIV	22	22	32%	34%
Political Science XVII	40	42	32%	29%
Psychology IX	12	10	34%	32%
	91	96	26%	26%
Sloan School of Management				
Management XV	75	81	22%	21%
XV-A (Fellows)	9	6	16%	11%
XV-B (Operations Research)	6	3	35%	21%
	90	90	21%	20%
School of Science				
Biology VII	33	32	26%	25%
VII-W	7	7	35%	37%
Chemistry V	35	47	17.5%	22%
Earth and Planetary Sciences XII	14	15	16%	18%
XII-W	11	14	34%	36%
Mathematics XVIII	21	24	18%	20.5%
Meteorology and Physical Oceanography XIX	4	6	9%	13%
XIX-W	4	5	31%	38%
Nutrition and Food Science XX	64	67	38%	42%
Physics VIII	27	29	9%	10%
Interdisciplinary Science XXV	11	5	61%	45.5%
	231	251	19%	22.3%
HST	1	4	8%	23.5%
TOTALS	779	828	18%	18.2%

TABLE VIII

WOMEN GRADUATE STUDENT ENROLLMENT

(% of Total 1973-1981)

	New			Continuing			Total		
Fall Term	Women	Total	% of Women	Women	Total	% of Women	Women	Total	% of Women
1973	105	1,080	10%	213	2,278	9%	318	3,358	9%
1974	140	1,061	13%	265	2,407	11%	405	3,468	12%
1975	175	1,113	16%	312	2,490	12.5%	487	3,603	13.5%
1976	185	1,220	15%	361	2,554	14%	546	3,774	14%
1977	192	1,184	16%	367	2,640	14%	559	3,824	14.6%
1978	218	1,259	17%	388	2,685	14%	606	3,944	15.4%
1979	193	1,202	16%	491	2,944	16.6%	684	4,146	16.4%
1980	254	1,308	19%	525	3,076	17%	779	4,384	18%
1981	243	1,272	19%	585	3,269	18%	828	4,541	18%

TABLE IX

COMPARISON OF ADMISSIONS STATISTICS FOR GRADUATE WOMEN AND GRADUATE MEN

Number of Applicants 1980/Number of Applicants 1981

Numbers in parenthesis indicate the percent change in number of applicants from 1980 to 1981

	Women	Men
School of Architecture and Planning	334/279 (-16%)	634/609 (- 4%)
School of Engineering	254/306 (+20%)	2716/2830(+ 4%)
School of Humanities and Social Science	156/176 (+13%)	446/488 (+ 9%)
Sloan School of Management	428/451 (+ 5%)	1631/1661(+1.8%)
School of Science	456/429 (- 6%)	1300/1327(+ 2%)
TOTALS	1628/1641(+ 1%)	6727/6915(+2.8%)

TABLE X

COMPARISON, IN NUMBERS, OF DEGREES AWARDED TO MEN AND WOMEN

1973-74 to 1981-82

	Master's			Doctor's			Engineer's			All		
	Women	Total	% of Women	Women	Total	% of Women	Women	Total	% of Women	Women	Total	% of Women
1973-74	58	832	7%	34	378	9%	3	102	3%	92* 95	1,210* 1,312	7.6%* 7%
1974-75	80	856	9%	32	362	9%	0	107	0%	112* 112	1,218* 1,325	9%* 8.4%
1975-76	93	862	11%	33	390	8%	2	94	2%	126* 128	1,252* 1,346	10%* 9.5%
1976-77	145	971	15%	50	379	13.2%	2	91	2%	197* 198	1,350* 1,441	14.5%* 13.7%
1977-78	135	934	14%	48	425	11%	5	108	5%	183* 188	1,359* 1,467	13.4%* 12.7%
1978-79	145	968	15%	29	387	7%	2	65	3%	174* 176	1,355* 1,420	12.8%* 12.3%
1979-80	156	984	16%	47	386	12%	3	77	4%	203* 206	1,370* 1,447	14.8%* 14%
1980-81	184	1,018	18%	65	396	16%	3	72	4%	249* 252	1,414* 1,486	17.6%* 16.9%
1981-82	214	1,118	19%	49	403	12%	5	64	8%	263* 268	1,521* 1,585	17.3%* 16.9%

* without engineer's degrees

TABLE XI

DEGREES AWARDED TO WOMEN BY SCHOOL
(Sept., Feb., June)

	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82
Architecture and Planning											
Master's*	12	23	13	23	23	34	23	33	41	48	51
Doctor's	1	1	1	2	0	2	4	3	5	6	2
Engineering											
Master's	12	14	22	16	21	28	42	50	51	62	84
Doctor's	2	0	3	3	3	8	4	4	7	14	10
Humanities and Social Sciences											
Master's	2	0	3	4	3	5	4	3	3	3	5
Doctor's	5	10	10	8	10	10	12	4	12	14	10
Sloan											
Master's	10	3	11	21	26	46	40	45	34	49	47
Doctor's	0	0	0	0	0	0	2	0	1	1	0
Science											
Master's	6	11	9	16	19	32	25	14	27	21	25
Doctor's	23	13	20	19	19	28	23	18	20	26	23
Operations Research (XV-B)											
Master's	0	0	0	0	1	0	1	0	0	1	2
Doctor's	0	0	0	0	0	0	1	0	0	2	0
WHOI											
Doctor's	0	0	0	0	1(VII-W)	2(VII-W) (XII-W)	2(VII-W) (XII-W)	0	2(VII-W) (XII-W)	2(XII-W)	3(XII-W) 1(XIX-W)
TOTALS											
Master's	42	51	58	80	93	145	135	145	156	184	214
Doctor's	31	24	34	32	33	50	48	29	47	65	49

*M. Arch., M.C. P., S.M.

TABLE XII

TRENDS IN MINORITY GRADUATE ENROLLMENT AT MIT

Minority Graduate Enrollment

School	1974	1975	1976	1977	1978	1979	1980	1981
Architecture and Planning	41	50	59	44	46	45	57	41
Engineering	38	38	44	40	44	47	58	55
Management	10	9	17	20	13	9	16	10
Humanities and Social Sciences	34	30	27	21	16	9	15	9
Science	28	28	31	32	28	34	25	25
Total Minority Enrollment	151	155	178	157	147	144	171	140
Total All Graduate Students	3,468	3,603	3,744	3,824	3,944	4,146	4,327	4,435

Black Graduate Enrollment

School	1974	1975	1976	1977	1978	1979	1980	1981
Architecture and Planning	34	39	45	34	32	34	40	30
Engineering	26	25	25	25	33	33	37	35
Management	10	8	13	17	12	8	16	10
Humanities and Social Sciences	31	26	23	17	14	9	12	5
Science	22	21	24	21	20	20	16	17
Total	123	119	130	114	111	104	121	97

Minority and Black Graduate Enrollment as Percent of Total Graduate Enrollment

Year	Total Grad. Enrollment	Minority Grad. Enrollment	% of Total	Black Grad. Enrollment	% of Total
1970-71	3,296	-	-	55	1.6%
1971-72	3,250	-	-	88	2.7%
1972-73	3,328	108	3.2%	87	2.6%
1973-74	3,358	121	3.6%	97	2.9%
1974-75	3,468	151	4.3%	123	3.5%
1975-76	3,603	155	4.3%	119	3.3%
1976-77	3,774	178	4.7%	130	3.4%
1977-78	3,824	157	4.1%	114	2.9%
1978-79	3,944	148	3.8%	111	2.8%
1979-80	4,146	144	3.5%	104	2.5%
1980-81	4,327	171	3.9%	121	2.8%
1981-82	4,435	140	3.1%	97	2.2%

TABLE XIII

TOTAL AND MINORITY REGULAR* GRADUATE ENROLLMENT

FALL 1981

	BA	PR	MA	AI	Total Minority Graduate Students	Total Graduate Students	% of Total
Architecture and Planning							
Architecture	13 (3)	4	2	0	19 (3)	244	7.7
Urban Studies Planning	17 (4)	2	0	3 (1)	22 (5)	145	15.1
	30 (7)	6	2	3 (1)	41 (8)	389	10.5%
Engineering							
Aeronautics and Astronautics	1	2 (2)	2 (1)	0	5 (3)	176	2.8
Chemical Engineering	6 (2)	0	1 (1)	0	7 (3)	229	3.1
Civil Engineering	1	1	0	0	2	246	0.8
Electrical Engineering and Computer Science	19 (3)	3 (2)	3 (2)	0	25 (7)	567	4.6
Materials Science and Engineering	2	0	0	0	2	235	0.9
Mechanical Engineering	5 (2)	2 (1)	5	0	12 (3)	382	3.1
Nuclear Engineering	1	0	1	0	2	154	1.3
Ocean Engineering	0	0	0	0	0	167	0.0
	35 (7)	8 (5)	12 (4)	0	55(16)	2,156	2.5%
Sloan School of Management	10 (2)	0	0	0	10 (5)	442	2.3%
Humanities and Social Science							
Economics	3	1	0	1	5	117	4.3
Linguistics and Philosophy	0	0	0	0	0	55	0.0
Political Science	2 (1)	1	1 (1)	0	4 (2)	118	3.4
Psychology	0	0	0	0	0	31	0.0
	5 (1)	2	1 (1)	1	9 (2)	321	2.8%
Science							
Biology	1 (1)	2	0	0	3 (1)	145	2.1
Chemistry	6 (1)	1	1	0	8 (1)	213	3.8
Earth and Planetary Sciences	0	0	0	0	0	120	0.0
Interdisciplinary	0	0	0	0	0	11	0.0
Mathematics	1	0	1	0	2	108	1.9
Meteorology and Physical Oceanography	0	0	0	0	0	58	0.0
Nutrition and Food Sciences	1	0	0	0	1	160	0.6
Physics	8 (1)	2	1	0	11 (1)	295	3.7
	17 (3)	5	3	0	25 (3)	1,110	2.3%
HST	0	0	0	0	0	17	0.0%
TOTALS	97(20)	21 (5)	18 (5)	4 (1)	140(34)	4,435	3.1%

( ) = new students

BA - Black Americans, PR - Puerto Ricans, MA - Mexican Americans, AI - American Indians

* Does not include 5 minority non-resident students of 106 total non-resident students.

TABLE XIV

MINORITY GRADUATE ADMISSIONS STATISTICS

Fall 1981

School	Number Applied	Number Admitted	Number Enrolled	Yield
Architecture and Planning	49	19	8	42%
Engineering	47	28	16	57%
Sloan School of Management	63	14	5	36%
Humanities and Social Sciences	13	5	2	40%
Science	38	5	3	60%
TOTALS	210	71	34	48%

Medical Department

This has been an extraordinary year. For more than two years we had been preoccupied with "pre-occupancy planning," and this year saw that effort tested -- we occupied our new building. After extensive delays, we moved.

On the holiday weekend in February, the Department moved out of Buildings 11, W-5, and 12 into E23. Our goal had been to effect the transfer without interrupting in-patient services -- and we did it. The level of enthusiastic participation by people both within and without the Department was astonishing. At 2:30 pm on Sunday, February 14, 1982, the Carleton Street doors opened wide to admit the first inpatient. The sentimental among us also noticed that it was, to the day, the anniversary of the death of Albert O. Seeler.

The delay in occupying our new quarters compressed the interval between moving and the dedication ceremonies to a little more than two weeks. An unexpected dividend was a carry-over of excitement and spirit which made it possible to accommodate about 1,000 visitors to our open-house tours conducted by a group of tour guides drawn from every level of the Department

The year has seen a succession of "firsts," the most recent of which was the performance of the first contrast X-ray study at MIT. This capability afforded by our new building will make possible a significant increase in convenience for our patients.

The Health Services Center also includes the first MIT Pharmacy -- licensed as a hospital pharmacy for our patients only. It is quite apparent that a need for this service exists, judging from the level of activity with which Chief Pharmacist David Bailey has had to cope from opening day.

Our new facility permits expansion of the link with the Athletic Department through the Sports Medicine program. It is now possible for the Medical Department to provide greatly increased orthopedic coverage in the Athletic Center and to offer medical support for Paul Grace, coordinator of Sports Medicine.

The Health Services Center has eliminated the "walk-in clinic." This entity has disappeared as the Internal Medicine service has been reorganized into four "clusters," each containing physicians and other providers of health care. This arrangement has decentralized our nursing staff, facilitating closer working relationships among doctors and their non-physician colleagues. Walk-in patients continue, of course, to be accommodated, but now in a way which will encourage greater continuity of care. With the support of Dr. Michael Kane, the clusters have begun an evolution in function which we hope will lead to dynamic interaction among professionals for the benefit of patients ("teams").

Our new facility required a re-licensing inspection for the Department as a licensed hospital. We passed the re-licensing inspection, and the experience was seen by many as useful, if only as a preparation for accreditation by the Joint Commission on Accreditation of Hospitals. This remains a major goal for the coming year.

Some of our major concerns for the year ahead are:

- Definition of professional commitment: What is "full-time?"
- The clinical laboratory: How can we control the enormous expense of laboratory tests for our patients?
- Peer-help and self-help: What should the Department be doing in these areas which have traditionally received little accent at MIT?
- Integration of medical records: How can we unify records in medicine, dentistry, psychiatry, and the Clinical Research Center?

- Information processing systems: What does the Department need; how can we maintain our current level of function manually while we determine our needs?

This last concern is quite profound. It has become all too clear that we have outgrown the capabilities of our current information processing systems. This is reflected in the difficulty of reporting with confidence various types of information, including utilization statistics and student enrollment medical data, and of monitoring diagnosis codes, protocol compliance, fiscal and billing information, etc. We must make major changes soon.

Participation in IAP exceeded even the previous year's level, by nearly a factor of two. Members of the Department gave 52 lectures on a wide range of topics and engaged the participation of 1,596 people, the majority of whom were students.

Our first primary care internal medicine resident, Dr. John Ingard, finished his residency on July 1, 1982. One additional full-time and one part-time resident will join us this coming year. Dr. William Ruth will formally join the program as a preceptor in addition to Dr. Michael Kane. Patients and medical staff have felt very positive about this program.

Staff Changes

Again, the number of changes in personnel was small; the appointments list includes many long-time Department employees who have been appointed to the staff this year. Included, too, is Dr. Charles Hatem who has, for many years, been "our man at Mount Auburn" for many of our patients admitted to that hospital. His appointment formalizes that relationship.

To be particularly noted are two changes within the nursing service. Pauline Jones has, for the past three years, been devoting much of her time and energy to the difficult and important task of keeping track of our patients admitted to outside hospitals. She is now so clearly essential to the function of that growing program that she has been designated Special Assistant to the Medical Director, Coordinator of Outside Clinical Services. As Mrs. Jones's attention to outside hospitals has increased, so has Deborah Dacus's involvement in the internal affairs of the nursing service. It has thus been possible to promote both of these devoted members of the staff in acknowledgment of their extraordinary efforts.

APPOINTMENTS

David E. Bailey
Pharmacist

Cheryl Birchette-Pierce
Physician

Ann Butman
Supervisor, Accounting and Billing Service

Monique Cantin
Nurse Practitioner

Rodney Edwards
Supervisor, Medical Record Services

Deborah Greenman
Postdoctoral Fellow
Psychiatry

Alison Grice-Knott
Manager of Information Systems

Sharon Haggerty
Nurse Practitioner

Charles Hatem
Physician

Brenda Lindemann
Assistant Coordinator for Health Education and Information

Kenneth MacAskill
Maintenance and Safety Coordinator

Mary Markunas
Claims Administrator, MIT Health Plans

Leslie Patton
Claims Administrator, MIT Health Plans

George Petievich
Assistant Director for Operations and Systems

Howard Ramseur
Psychologist

Sharmon Randall
Administrator, Psychiatry and Social Work Services

Kathleen Reid
Administrator, Psychiatry and Social Work Services

Elaine Li Shiang
Physician

Howard Smith
Otolaryngologist

RESIGNATIONS

Laurent Delli-Bovi
Obstetrician/Gynecologist

Elaine Dors
Nurse Practitioner

RESIGNATIONS (cont.)

Iris Goldberg
Assistant Coordinator for Health Education and Information

Martha Loss
Manager, Medical Information Services

Mary Markunas
Claims Administrator, MIT Health Plans

Humphrey Morris
Postdoctoral Fellow Psychiatry

Sharmon Randall
Administrator, Psychiatry and Social Work Services

George Simpson
Otolaryngologist

Toni Beth Walzer
Obstetrician/Gynecologist

Sally Zinno
Operations Manager

Mary Zook
Nurse Practitioner

PROMOTIONS

Deborah Dacus
Director of Nursing Services

Pauline Jones
Special Assistant to the Medical Director, Coordinator of Outside Clinical Services

F. Judith Klayman
Assistant Operations Manager

James Manson
Chief of Orthopedic Services

Janet M. Wright
Assistant Operations Manager

CHANGE

William Ruth
Acting Medical Officer, Environmental Medical Service

Level of Activity

The overall figures, which show a very small decline in number of visits compared with a year ago (118,956 this year, off 2,149) obscure a very interesting phenomenon. Utilization of the Department's services has increased in all major locations except one, nursing. This is the designation used for services provided to ambulatory patients by our nurse-practitioners and physician-assistants.

The total visits to the nursing service declined by 3,956 (-17.8 percent) this year; students made 1,965 fewer visits to these non-physician providers (-19.4 percent). At the same time, visits to other primary care providers increased; for example, visits to Internal Medicine increased by 1,213 (+5 percent). Students, reversing recent trends, actually increased their visits to internists by 9.6 percent.

Among the explanations for these observations, one might offer the following:

1) A decrease in visits would be expected due to the move to our new building and its location. Indeed, utilization of the Department's services was very low during February, the month of the move. Utilization in the March through May quarter (after relocation) was down by 1,100 visits from the same quarter the previous year. The difference would be expected to be largely in the "walk-in" category.

2) Students and other patients may be heeding our urging to "pick a physician to be your doctor" hence using physician services more and walk-in (nursing) services less.

3) Two physicians joined the Department during the year, increasing the available physician time. As a rule, available physician time gets filled.

4) It might be possible that patients' needs can be accommodated by physicians in fewer visits than are required by non-physician providers.

We need to continue careful scrutiny of these activities. A study of visits -- per-illness by type of provider (M.D. vs. non-M.D.) will be undertaken.

It is clear, through all of this, that our patients continue to use our services at a fairly intense level.

VISITS TO DEPARTMENT (by fiscal year)

	1982	1981	DIFFERENCE 1981-82 (%)
TOTAL VISITS	118,986	121,105	-1.7
Internal Medicine	25,861	24,648	+5
by students	9,055	8,260	+9.6
Nursing	18,252	22,208	-17.8
by students	8,146	10,111	-19.4
Orthopedics	5,667	4,576	+23.8
by students	2,148	1,707	+25.8
Gynecology/Obstetrics	7,761	7,627	+1.7
by students	1,605	1,451	+10.6
Total by Students (less Dental)	33,955	35,479	-4.3
Health Plan Total (less Dental)	47,763	46,944	+1.7
Average Visits/Student	3.85	4.0	
Average Visits/Health Plan Member	> 6	> 6	

Dental Service

The number of patients seen increased this year. With the new facility, increased efficiency should make even further increases possible. The monthly staff meetings and educational sessions continue. A health education program has been started with the goal of decreasing the incidence of caries and periodontal disease. The study of the use of analgesics is nearing completion.

Psychiatry Service

The continuing social and economic pressures on young postdoctoral fellows and graduate students and on their families is reflected in significantly increased use of the Psychiatric Service. The same trend is noticeable among faculty and staff, while usage of the service by employees and other community members remained relatively constant. Overall, there was a modest rise this year in the total number of patients as well as in the total number of visits.

Although Infirmary use declined, the number of hospitalizations increased by 50 percent over last year. Health Plan members account almost completely for this increase; student hospitalizations actually declined slightly.

Of the 1,707 persons consulting the service, approximately two-thirds were managed in brief consultations and group therapy. Most of those referred for continuing therapy were sent to private practitioners and clinics in the greater Boston area.

Group therapy -- including family, couple, parenting, and other specialized groups -- now comprises about 25 percent of total visits. In addition, various staff members participate regularly in supportive group activities, such as the Wives' Group and Women's Forum, and as ad hoc consultants to living groups and academic departments.

Social Work Service

The increase in use of clinical services during the previous year has been sustained this past year. Work with individuals, couples, and families, as well as special support groups (e.g., single parents, people with alcohol problems, minority students, and a newly formed working-women group) continues. An average of about 275 clinical visits occur each month; about 500 people are seen each year. Members of the Social Work Service staff interact with minority students, Light Line staff, the Women Student Interest group, Tech Child Care Committee, Interphase students, supervisors of employees, the Institute Privacy Committee, and the Black Administrators group.

The Institute Personal Assistance Program has had more than 300 referrals since its inception. Training and orientation continue to be provided for managers and supervisors on campus and at the Lincoln and Draper laboratories. A recovery or improvement rate of about two in every three referrals has been experienced. Alcohol problems constitute the largest presenting problem (about 35 percent). Hospitalization has been required in less than one-half of these patients.

Obstetrics and Gynecology

Although there was only a small increase in overall use of this service (less than 2 percent) students increased their visits by 10.6 percent. Once again, we face a change in the physician component; Dr. Toni Walzer has left to join the Harvard Community Health Plan, where she anticipates an opportunity for much more surgical experience than our population of patients requires. We anticipate trying a different combination of health care professionals in an attempt to meet our patients' needs.

MIT Health Plan

In its ninth year of operation, the MIT Health plan experienced a solid achievement in enrollment. After virtually no growth in 1981, the number of employees enrolled by the end of this year grew by 6.4 percent to nearly 3,800 subscribers. This is the product of two separate enrollment trends. Enrollment at MIT grew by 9 percent while at the Draper Laboratory it decreased by 11 percent. The Draper Laboratory enrollment decline may be attributed to two factors: The overall population at Draper shrank slightly this year, but more importantly the MIT Health Plan costs significantly more than the other two health benefit options. This was distinctly different from the situation on campus where the cost to employees was less than that of the Master Medical Plan. Clearly, price is an important variable in determining which plan people will choose.

In a study of enrollment patterns, we found this year that 40 percent of the eligible people on the main campus have enrolled in the MIT Health Plan. It is difficult to project much further growth in light of this fact, particularly with increased competition in the Boston area for health consumers' dollars. Ten health maintenance organizations are now in existence in the metropolitan area. We must decide on alternative strategies to hold our market share in the years ahead.

This year, use of hospital services returned to a more acceptable rate: 399 days per 1,000 members in acute care hospitals. In fiscal year 1981, the rate had risen to 436 days per 1,000 members. Admissions for mentally ill patients remain very high, accounting for about 25 percent of the total bed days. Use of ambulatory services also remains high at 6.1 visits per member per year. The relocation of our facility some distance from the center of the campus may reduce this, but the number of visits per member has remained the highest of any health maintenance organization in the nation.

Environmental Medical Service

Under the superb leadership of Richard Chamberlin, acting director, this Service has continued to provide the basic ongoing programs which have proven their value in the past. Each group within the Service also has some additional concerns which will require attention in the near future. The Industrial Hygiene Office must develop a protocol for evaluating the "non-specific" health effects of what is often referred to as "indoor air pollution." The Radiation Protection Office, having experienced a respite from waste disposal problems, must develop definitive programs by 1985. The Biohazard Assessment Office must deal with reclassification of biological agents.

The pesticide control program under the direction of Dr. Gary Alpert, entomologist consultant, has already proven quite effective. There has been a reduction not only in the quantity of pesticide used but also in the frequency of application required.

The efforts of Dr. Constantine J. Maletskos to create a research program within EMS have shown commendable progress, given the present economic climate and dearth of research funds. His approach has involved the development of projects which invite the collaborative interest of other MIT groups.

As an index of the range of service programs provided to the Institute, Lincoln Laboratory, Bates Linear Accelerator, and Draper Laboratory by the Environmental Medical Service, the following partial list is offered:

Laboratory hood surveillance; testing of filters for hood exhaust systems; respiratory protection program -- provision of respirators; hearing conservation program; testing of air and biologic samples for evaluation of exposure to hazardous materials; lead screening program; proficiency testing; design and evaluation of hazard control systems; hazard control ventilation involved in modifying buildings and in new construction; training sessions for Physical Plant maintenance personnel; pesticide control program; "odor complaints" program; review of authorizations for radioisotope use; radioisotope laboratory surveys; survey instrument calibration and repair; monitoring and transportation of radioisotope packages; radioactive waste program; counting room (whole body *in vivo* counting); central radioisotope laboratory and storage facility; laser, microwave, and X-ray programs; Alcator radiation protection program; radiation safety training programs; Bates Linear Accelerator programs in radiation protection: personnel monitoring and environmental monitoring; reactor radiation protection activities: air sampling, water sampling, radioactive waste collection, calibration of instrumentation, environmental monitoring systems; autoclave certification program which includes instruction of personnel and the distribution, collection, and analyses of indicators to verify function of autoclaves; many training programs; periodic monitoring of all recombinant DNA research labs; review of RDNA research programs; participation in development of infectious waste management programs; environmental surveys for biohazards; and screening of individuals working with carcinogens.

Radioactivity Center

Since its establishment in 1934, the Center has studied the effects of radiation on human subjects. Observations on radium dial painters over the course of many years have, for example, been accomplished. A large quantity of useful data has been acquired, and many studies have been published. Participants from the Medical Department have included Dr. Samuel D. Clark, Dr. John Gary, and, most recently, Dr. Melvin H. Chalfen.

Since 1970, the MIT Center has been funded through an arrangement with the Argonne National Laboratory's Center for Human Radiobiology. On September 30, 1981, funding for the Radioactivity Center at MIT ceased.

The counting chamber constructed of aged battleship steel ("the iron room"), unneeded for other uses, will be disassembled soon.

MELVIN H. RODMAN

Division of Comparative Medicine

The Division of Comparative Medicine continued to grow over the year both in responsibility and in total space for animal experimentation. The new Whitaker complex, which was recently opened, encompasses approximately 16,000 square feet of animal holding space. The total space now managed by DCM encompasses more than 65,000 gross square feet. With the addition of the new animal facility in the Health Sciences and Technology building, the Building 37 animal facility has been phased out, and the investigators relocated into the HST space.

The Psychology E10 animal care facility continues to be the only unit carried on DCM inventory that is substandard. The resolution of the fate of this facility must be addressed within the next year.

The MIT animal care and use program continues to be fully accredited by the Association for the Accreditation of Laboratory Animal Care.

During the past year, the Division purchased and produced approximately 100,000 animals. It was also responsible for the health monitoring of an additional estimated 350,000 animals on an annual basis. Because of the economic downturn, the daily census of animals at MIT has been reduced by approximately 10 to 15 percent. However, we expect this number will again increase with the opening of the new facility in the HST complex. The Research Animal Diagnostic Laboratory continues to be responsible for diagnostic services for more than 82,000 animals a day, including those housed at MIT as well as at many research institutions throughout the Boston area.

The Division's Research Animal Diagnostic Laboratory (RADL) has now been in operation for six years. The funds for operating this laboratory are generated from the National Institutes of Health and from services provided to several outside research institutions in the Boston area. I am pleased to report that the renewal application submitted to NIH for a competing three-year renewal has been approved and funded. This unit will therefore continue to provide diagnostic services for the Institute and the Boston biomedical community.

The Division remains active in teaching undergraduates, graduates, and summer veterinary students. In addition, we have initiated a postdoctoral training program for graduate veterinarians in Comparative Medicine. We have successfully recruited two excellent veterinarians to fill these positions. We offer the course entitled Laboratory Animals: Usage in Biomedical Experimentation; we also offer a core course, Analytical Practices in Biochemistry -- a series of techniques basic to analytical biochemistry. The pathologists on the staff assist in teaching a third course entitled Nutritional Pathology. Finally, we have been involved in the Undergraduate Research Opportunities Program and, during the summer of 1981, tutored three veterinary students.

Independent and collaborative research programs continue to be active and expanding. The Division staff has successfully completed clinical and collaborative investigations, independent research experiments, and critical reviews resulting in eight published articles during the year; another four articles are in press. The staff also has presented eight papers as invited speakers at symposia, national meetings, and university-sponsored lectures. After a four-year effort, the publication of a four-volume set of books entitled *The Mouse in Biomedical Research* has been completed. At present, DCM has nine funded grants or contracts of which DCM staff are either the principal investigators or co-principal investigators.

Finally, I am pleased to report several additions to our staff: Dr. Christian Newcomer joined our staff on July 15, 1981, as clinical veterinarian, with additional active interests in research and teaching. Dr. Carolyn Craft Moyer joined us on August 15, 1981, as assistant professor in Comparative Pathology. On July 1, 1982, Dr. Steven Niemi and Dr. Alice Liberson will join our staff as postdoctoral fellows in Comparative Medicine. We also have appointed as a research associate Ms. Nancy Taylor, who has had extensive experience in biochemistry and toxin purification.

JAMES G. FOX

REGISTRAR

All statistics on Registration and Staff in the following tables are given as of the fifth week of the Fall Term, except: 1943-44 as of August 2, 1943; 1944-45 as of November 27, 1944; and 1945-46 as of July 30, 1945.

TABLE I STUDENT REGISTRATION SINCE THE FOUNDING OF THE INSTITUTE *

YEAR	NUMBER OF STUDENTS	YEAR	NUMBER OF STUDENTS	YEAR	NUMBER OF STUDENTS
1865-66	72	1906-07	1,397	1946-47	5,172
1866-67	137	1907-08	1,415	1947-48	5,662
1867-68	167	1908-09	1,461	1948-49	5,433
1868-69	172	1909-10	1,479	1949-50	5,458
1869-70	206	1910-11	1,506	1950-51	5,171
1870-71	224	1911-12	1,559	1951-52	4,874
1871-72	261	1912-13	1,611	1952-53	5,074
1872-73	348	1913-14	1,685	1953-54	5,183
1873-74	276	1914-15	1,816	1954-55	5,348
1874-75	248	1915-16	1,900	1955-56	5,648
1875-76	255	1916-17	1,957	1956-57	6,000
1876-77	215	1917-18	1,698	1957-58	6,179
1877-78	194	1918-19	1,819	1958-59	6,259
1878-79	188	1919-20	3,078	1959-60	6,270
1879-80	203	1920-21	3,436	1960-61	6,289
1880-81	253	1921-22	3,505	1961-62	6,454
1881-82	302	1922-23	3,180	1962-63	6,695
1882-83	368	1923-24	2,949	1963-64	6,925
1883-84	443	1924-25	2,938	1964-65	7,151
1884-85	579	1925-26	2,813	1965-66	7,408
1885-86	609	1926-27	2,671	1966-67	7,567
1886-87	637	1927-28	2,712	1967-68	7,730
1887-88	720	1928-29	2,868	1968-69	7,764
1888-89	827	1929-30	3,066	1969-70	8,024
1889-90	909	1930-31	3,209	1970-71	7,799
1890-91	937	1931-32	3,188	1971-72	7,717
1891-92	1,011	1932-33	2,831	1972-73	7,850
1892-93	1,060	1933-34	2,606	1973-74	7,888
1893-94	1,157	1934-35	2,507	1974-75	8,050
1894-95	1,183	1935-36	2,540	1975-76	8,482
1895-96	1,187	1936-37	2,793	1976-77	8,597
1896-97	1,198	1937-38	2,966	1977-78	8,712
1897-98	1,198	1938-39	3,093	1978-79	8,881
1898-99	1,171	1939-40	3,100	1979-80	9,053
1899-00	1,178	1940-41	3,138	1980-81	9,365
1900-01	1,277	1941-42	3,055	1981-82	9,510
1901-02	1,415	1942-43	3,048		
1902-03	1,608	1943-44	1,579		
1903-04	1,528	1944-45	1,198		
1904-05	1,561	1945-46	1,538		
1905-06	1,466				

*From 1943 to 1946 Army and Navy students are omitted (see Table III-B in reports for 1943 to 1946)

TABLE I-A STUDENT REGISTRATION IN THE SUMMER SESSION SINCE 1948

YEAR	*IN REGULAR SUBJECTS	+IN OTHER SUBJECTS	YEAR	*IN REGULAR SUBJECTS	+IN OTHER SUBJECTS
1948	2,146	-	1968	2,490	1,739
1949	1,875	171	1969	2,241	1,719
1950	1,852	259	1970	2,185	1,666
1951	1,861	813	1971	2,197	1,109
1952	1,689	832	1972	2,121	1,235
1953	1,672	1,289	1973	2,205	1,367
1954	1,675	1,398	1974	2,153	1,701
1955	1,619	1,653	1975	2,238	1,430
1956	1,553	2,497	1976	2,317	1,614
1957	1,548	1,757	1977	2,321	1,724
1958	1,650	1,752	1978	2,344	1,611
1959	1,635	1,510	1979	2,610	1,748
1960	1,600	1,696	1980	2,627	1,720
1961	1,668	1,412	1981	2,685	1,722
1962	1,748	1,763			
1963	1,808	1,397			
1964	1,882	1,492			
1965	2,090	1,568			
1966	2,054	1,787			
1967	2,218	1,829			

*Students attending regular subjects from M.I.T. curricula .
+Students attending professional subjects which are not part of M.I.T. curricula and in general carry no academic credit.

TABLE II ACADEMIC STAFF COUNT

	Professors*	Administration also Professors*	Institute Professors Emerti-Part Time*	Adjunct Professors*	Associate Professors*	Assistant Professors*	Sr. Lecturers and Professors Emeriti*	Sr. Lecturers	Lecturers	Sr. Research Scientists	Instructors	Technical Instructors	Sr. Research Associates	Postdoctoral Associates	Research Assistants	Teaching Assistants	Instructor Grad	Total	Visiting Professors	Others1
Institute Professors	12	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	1	-
SCHOOL OF ARCHITECTURE AND PLANNING																				
Architecture	14	2	-	5	12	9	-	-	10	-	4	7	-	-	12	36	1	112	7	20
Urban Studies and Planning	12	-	-	1	9	4	-	-	3	-	1	-	-	-	19	1	11	61	4	13
Total	26	2	-	6	21	13	-	-	13	-	5	7	-	-	31	37	12	173	11	34
SCHOOL OF ENGINEERING	1	2	-	-	3	-	2	-	1	-	-	-	-	-	-	-	-	9	-	3
Aeronautics and Astronautics	25	2	-	2	6	5	3	5	13	-	-	3	-	3	98	3	-	168	2	15
Chemical Engineering	11	3	-	2	10	5	2	1	2	-	4	2	-	-	81	40	1	164	4	23
Civil Engineering	17	2	-	-	19	8	1	5	-	-	-	-	1	5	107	16	2	183	5	18
Electrical Engineering and Computer Science	50	13	-	4	25	19	3	1	10	2	-	1	1	4	222	114	1	470	4	25
Materials Science and Engineering	23	1	-	1	8	5	1	-	-	-	-	2	1	8	149	26	1	226	1	37
Mechanical Engineering	27	3	-	-	17	11	1	5	17	2	-	6	1	4	203	15	-	312	5	22
Nuclear Engineering	14	2	-	1	3	4	1	-	-	-	-	-	1	1	58	15	1	101	2	13
Ocean Engineering	10	-	-	1	7	5	-	-	-	-	-	-	-	1	44	12	-	80	2	12
Total	178	28	-	11	98	62	14	17	43	4	4	14	5	26	962	241	6	1,713	25	168
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE	-	-	-	-	-	-	-	-	4	-	1	2	-	-	-	-	-	7	-	4
Economics	17	1	-	-	3	6	-	-	-	-	-	-	-	-	11	28	-	66	5	10
Humanities	18	2	-	-	29	23	-	2	29	-	12	9	-	-	-	-	-	124	5	10
Linguistics and Philosophy	14	1	-		2	3	-	-	-	-	-	-	-	1	22	13	1	57	2	17
Political Science	14	2	-	-	4	7	-	1	-	-	-	-	-	-	10	9	-	47	-	8
Psychology	8	1	-	-	5	-	-	-	1	-	-	3	-	6	6	-	-	30	-	25
Science, Technology, and Society	5	1	-	-	5	2	-	-	-	-	-	-	-	-	-	-	-	13	2	7
Total	76	8	-	-	48	41	-	3	34	-	13	14	-	7	49	50	1	344	14	81
Alfred P. Sloan School of Management																				
Management	35	2	-	4	15	22	2	6	4	-	-	2	-	1	30	27	2	152	3	32
SCHOOL OF SCIENCE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	2	-	1
Biology	25	2	-	-	9	3	1	-	-	-	2	-	1	52	26	-	-	121	3	77
Chemistry	22	2	-	-	3	5	3	-	1	-	-	3	-	50	133	48	-	270	-	51
Earth and Planetary Sciences	14	1	-	-	6	4	-	-	-	1	1	-	1	8	67	10	-	113	1	20
Mathematics	37	1	-	-	6	13	-	-	5	-	21	-	-	-	8	57	-	148	5	23
Meteorology and Physical Oceanography	5	1	-	-	2	5	-	-	-	-	-	-	-	3	40	2	-	58	1	10
Nutrition and Food Science	12	2	-	1	12	4	1	4	10	1	1	-	-	21	58	18	-	145	2	98
Physics	56	6	-	-	19	10	-	-	-	10	1	4	-	15	211	34	-	366	3	24
Total	171	15	-	1	57	44	5	4	16	12	26	7	2	149	544	170	-	1,223	15	304

Administration	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8
Aerospace Studies	–	–	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	9	1	–
Artificial Intelligence Laboratory	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1	–	7
Athletic	–	1	–	–	8	6	–	–	–	–	12	–	–	–	–	–	–	27	–	20
Center for Advanced Engineering Study	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
Center for Visual Study	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	25
Center for Cancer Research	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	33
Center for Cognitive Science	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	19
Center for International Studies	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	15
Center for Materials Science and Engineering	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	–	6
Center for Policy Alternatives	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	3	–	–
Center for Space Research	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1	–	3
Center for Transportation Studies	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Clinical Research Center	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	2	–	–
Division for Study and Research in Education	1	1	–	–	4	1	–	–	–	–	–	–	–	–	–	–	–	7	2	5
Division for Comparative Medicine	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	–	8
Energy Laboratory	–	–	–	–	–	–	–	–	–	2	–	–	–	2	–	–	–	4	–	28
Harvard-MIT Health Sciences and Technology	–	1	–	–	–	1	–	–	1	1	–	–	–	4	–	–	–	8	3	13
Laboratory of Architecture and Planning	–	–	–	–	–	–	–	–	–	1	–	—	–	–	–	–	–	1	–	8
Laboratory for Computer Science	–	–	–	–	–	–	–	–	–	1	–	–	–	2	–	–	–	3	–	17
Laboratory for Information and Decision Systems	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1	–	7
Laboratory for Nuclear Science	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9
Libraries	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	72
Materials Processing Center	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
Medical	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	144
Military Science	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	5	1	1
National Magnet Laboratory	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	2	–	24
Naval Science	–	–	–	–	–	–	–	–	–	–	–	11	–	–	–	–	–	11	1	–
Neurosciences Research Program	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
Nuclear Reactor Laboratory	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Office of the Provost	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1
Plasma Fusion Center	–	–	–	–	–	–	–	–	–	2	–	–	–	5	–	–	–	7	–	12
Research Laboratory of Electronics	–	–	–	–	–	–	–	–	–	1	–	–	–	9	–	–	–	10	–	65
Sea Grant Program	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Spectroscopy Laboratory	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13
Student Activities	–	–	–	–	–	–	–	–	–	–	–	7	–	–	–	–	–	7	–	–
Whitaker College of Health Science, Technology and Management	1	–	–	–	–	1	–	–	–	–	–	–	–	1	–	1	–	4	–	2
Total	4	5	–	–	12	9	–	–	1	13	12	32	3	27	–	1	–	119	8	579
Grand Total	502[2]	61[2]	1[2]	22[2]	251[2]	191[2]	21[2]	30[2]	111[2]	29	60[2]	76[2]	10	210	1,616	526[2]	21[2]	3,738	77[3,4]	1,198[3]
Faculty Ex-Officiis																		44*		
																		3,782		

*Total Faculty 1,093

[1]includes Administrative Officers, affliated Artists, Coaches and Trainers, Guests, Honary Lecturers, Visiting Lecturers and Senior Lecturer, Librarians, Medical Doctors, Postdoctoral and Research Fellows, Postdoctoral Trainees (Department of Chemistry), Research Affliates, Senior Research Engineer, Visiting Economists, Visiting Engineers, Visiting Scholars, Visiting Scientists.

[2]Total teaching staff 1,873

[3]Not included in preceding total

[4]Visiting Professors include 39 Professors, 21 Associate Professors, 17 Assistant Professors

TABLE III CLASSIFICATION OF STUDENTS SINCE 1979

	1979-80						1980-81					
	2	3	4	G	Non Res.[1]	Total	2	3	4	G	Non Res.[1]	Total
SCHOOL OF ARCHITECTURE AND PLANNING												
Architecture, IV	19	34	37	190	1	281	16	31	33	204	4	288
Architecture, IV-B	-	-	1	-	-	1	-	1	-	-	-	1
Urban Studies and Planning, XI	5	12	12	193	-	222	3	2	10	190	24	229
Total	24	46	50	383	1	504	19	34	43	394	28	518
SCHOOL OF ENGINEERING												
Aeronautics and Astronautics, XVI	70	39	33	167	-	309	78	53	45	192	-	368
Aeronautics and Astronautics, XVI-B (Cooperative)	-	1	3	-	-	4	-	6	2	-	-	8
Aeronautics and Astronautics, XVI-C (Internship)	-	7	5	-	-	12	-	12	8	-	-	20
Chemical Engineering, X	105	111	110	220	-	546	95	108	107	206	-	516
Chemical Engineering, X-C	2	-	7	-	-	9	4	1	4	-	-	9
Civil Engineering, I	32	40	68	268	-	408	23	34	48	290	2	397
Civil Engineering, I-A	-	-	-	-	-	-	1	-	1	-	-	2
Civil Engineering, I-W (Woods Hole)	-	-	-	4	-	4	-	-	-	3	-	3
Electrical Engineering and Computer Science, VI												
Program 1-Electrical Science and Engineering	224	166	151	521	-	1,332	250	158	168	568	2	1,449
Program 3-Computer Science and Engineering	108	71	91				100	111	92			
Electrical Engineering and Computer Science, VI-A (Cooperative)												
Program 1-Electrical Science and Engineering	-	64	56	78	-	250	-	65	83	74	-	266
Program 3-Computer Science and Engineering	-	23	29				-	20	24			
Electrical Engineering and Computer Science, VI-W (Woods Hole)	-	-	-	1	-	1	-	-	-	1	-	1
Materials Science and Engineering, III	29	22	23	186	-	260	24	23	23	213	-	283
Materials Science and Engineering, III-A	1	2	1	-	-	4	1	-	4	-	-	5
Materials Science and Engineering, III-B (Cooperative)	8	20	14	-	-	42	8	24	19	-	-	51
Materials Science and Engineering, III-W (Woods Hole)	-	-	-	1	-	1	-	-	-	1	-	1
Mechanical Engineering, II	106	115	112	357	-	690	111	101	120	405	-	737
Mechanical Engineering, II-A	12	16	27	-	-	55	8	13	25	-	-	46
Mechanical Engineering, II-B (Internship)	-	23	11	-	-	34	-	17	19	-	-	36
Mechanical Engineering, II-T (Textile Technology)	-	-	-	2	-	2	-	-	-	1	-	1
Mechanical Engineering, II-W (Woods Hole)	-	-	-	-	-	-	-	-	-	1	-	1
Nuclear Engineering, XXII	18	7	10	173	2	210	10	15	4	156	-	185
Nuclear Engineering, XXII-A (Internship)	-	3	1	-	-	4	-	3	3	-	-	6
Ocean Engineering, XIII	2	14	15	89	-	120	12	6	15	95	-	128
Ocean Engineering, XIII-C (Cooperative)	-	-	-	-	-	-	-	-	1	-	-	1
Ocean Engineering, XIII-W (Woods Hole)	-	-	-	9	-	9	-	-	-	8	-	8
Naval Construction and Engineering, XIII-A	-	-	-	49	-	49	-	-	-	50	-	50
Ocean Systems Management, XIII-B	-	-	-	4	-	4	-	-	-	11	-	11
Center for Advanced Engineering Study, EN	-	-	-	55	-	55	-	-	-	54	-	54
Total	717	744	767	2,184	2	4,414	725	770	815	2,329	4	4,643
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE												
Economics, XIV	10	14	21	127	5	177	14	16	20	116	14	180
Humanities and Engineering, XXI-A	-	-	4	-	-	4	1	3	2	-	-	6
Humanities and Science, XXI-B	6	11	17	-	-	34	3	11	17	-	-	31
Linguistics and Philosophy, XXIV	-	3	2	65	7	77	2	1	4	61	9	77
Political Science, XVII	7	13	16	108	31	175	7	9	12	106	28	162
Political Science, XVII-A (Public Policy)	-	-	-	-	-	-	-	2	4	-	-	6
Psychology, IX	-	-	-	33	2	35	-	-	-	35	-	35
Total	23	41	60	333	45	502	27	42	59	318	51	497
ALFRED P. SLOAN SCHOOL OF MANAGEMENT												
Management, XV	23	39	42	338	1	443	17	29	54	363	5	468
Management Fellows, XV-A	-	-	-	63	-	63	-	-	-	62	-	62
Management-Operations Research, XV-B	-	-	-	23	-	23	-	-	-	17	-	17
Total	23	39	42	424	1	529	17	29	54	442	5	547
SCHOOL OF SCIENCE												
Biology, VII	39	61	64	123	-	287	49	48	56	133	-	286
Biology, VII-A	6	4	20	-	-	30	-	9	14	-	-	23
Biology, VII-B	8	12	26	-	-	46	9	11	8	-	-	28
Biology, VII-W	-	-	-	19	-	19	-	-	-	20	-	20
Chemistry, V	41	52	37	191	-	321	48	35	48	202	-	333
Earth and Planetary Sciences, XII	15	18	18	77	2	130	6	14	15	86	2	123
Earth and Planetary Sciences, XII-W (Woods Hole)	-	-	-	44	-	44	-	-	-	32	-	32
Interdisciplinary Science Program, XXV	5	3	4	15	-	27	2	5	2	23	-	32
Mathematics, XVIII	34	33	51	113	4	235	43	40	41	121	5	250
Meteorology and Physical Oceanography, XIX	-	-	-	42	-	42	-	-	-	46	-	46
Meteorology and Physical Oceanography, XIX-W (Woods Hole)	-	-	-	12	-	12	-	-	-	13	-	13
Nutrition and Food Science, XX	-	-	-	192	-	192	-	-	-	171	1	172
Physics, VIII	85	79	82	274	-	520	75	85	86	310	-	556
Total	233	262	302	1,102	6	1,905	232	247	270	1,157	8	1,914
Health Sciences and Technology, HST	-	-	-	55	-	55	-	-	-	52	-	52
Undesignated	84					84	99					99
First Year	1,060					1,060	1,095					1,095
Grand Total	1,060	1,104	1,132[2]	1,221[2]	4,481	55 9,053	1,095	1,119[3]	1,122[3]	1,241[3]	4,692	96 9,365
(not included in above figures)												
Non-Institute students from Harvard		8	12	15	243	- 278		11	15	31	259	- 316
Non-Institute students from Wellesley		50	67	88	-	- 205		44	60	118	-	- 222

[1]Non-Resident students

[2]These totals include 13 students in third year and 3 students in fourth year on Foreign Study; 2 students in third year on Domestic Study.

[3]These totals include 8 students in third year, 4 students in fourth year on Foreign Study; 1 student in year two, 2 students in year 3, and 3 students in year four on Domestic Study.

[4]These totals include 8 students in third year, 2 students in fourth year on Foreign Study; 2 students in second year, 2 students in third year on Domestic Study.

	1981-82			Non		
2	3	4	G	Res.	Total	Course Number
29	21	35	250	6	341	IV
-	-	1	-	-	1	IV-B
1	5	4	173	32	215	XI
30	26	40	423	38	557	Total
90	65	52	185	-	392	XVI
-	4	5	-	-	9	XVI-B
1	10	11	-	-	22	XVI-C
127	98	110	231		566	X
-	6	4	-	-	10	X-C
20	30	40	257	1	348	I
-	1	1	-	-	2	I-A
-	-	-	5	-	5	I-W
236	167	181	551	-	1,463	VI
97	108	123				
-	62	70	90	-	272	VI-A
-	22	28				
-	-	-	3	-	3	VI-W
30	18	23	242	-	313	III
1	2	3	-	-	6	III-A
24	22	25	-	-	71	III-B
-	-	-	-	-	-	III-W
127	106	105	445	-	783	II
3	8	18	-	-	29	II-A
-	15	24	-	-	39	II-B
-	-	-	1	-	1	II-T
-	-	-	1	-	1	II-W
12	4	13	156	-	185	XXII
-	5	3	-	-	8	XXII-A
10	11	6	88	-	115	XIII
-	-	-	-	-	-	XIII-C
-	-	-	9	-	9	XIII-W
-	-	-	52	-	52	XIII-A
-	-	-	19	-	19	XIII-B
-	-	-	55	-	55	EN
778	764	845	2,390	1	4,778	Total
8	23	17	128	10	186	XIV
-	1	7	-	-	8	XXI-A
4	13	23	-	-	40	XXI-B
-	5	5	56	9	75	XXIV
-	9	18	130	28	185	XVII
-	-	2	-	-	2	XVII-A
-	-	-	31	-	31	IX
12	51	72	345	47	527	Total
14	22	37	392	6	471	XV
-	-	-	76	-	76	XV-A
-	-	-	14	-	14	XV-B
14	22	37	482	6	561	Total
36	51	50	132	-	269	VII
4	3	12	-	-	19	VII-A
6	13	11	-	-	30	VII-B
-	-	-	19	-	19	VII-W
42	47	39	216	-	344	V
10	11	19	82	2	124	XII
-	-	-	39	-	39	XII-W
3	2	2	11	-	18	XXV
37	48	52	115	9	261	XVIII
-	-	-	49	1	50	XIX
-	-	-	13	-	13	XIX-W
-	-	-	165	-	165	XX
86	69	84	298	2	539	VIII
224	244	269	1,139	14	1,890	Total
-	-	-	63	-	63	HST
96					96	Undesignated
1,038					1,038	First Year
1,038	1,154[4]	1,107[4]	1,263[4]	4,842	106	9,510	Grand Total
15	12	25	326	-	378	NIH
42	67	87	-	-	196	NIW

TABLE III-A WOMEN STUDENTS BY SCHOOLS, COURSES AND YEARS, 1981-82 [1]

COURSE	2	3	4	GRADUATE Regular	GRADUATE Non Resident	GRADUATE Special	TOTAL
SCHOOL OF ARCHITECTURE AND PLANNING							
Architecture, IV	11	5	14	73	4	1	108
Urban Studies and Planning, XI	1	4	1	63	17	8	94
Total	12	9	15	136	21	9	202
SCHOOL OF ENGINEERING							
Aeronautics and Astronautics, XVI	13	13	8	10	-	2	46
Aeronautics and Astronautics, XVI-B (Cooperative)	-	-	1	-	-	-	1
Aeronautics and Astronautics, XVI-C (Internship)	-	-	1	-	-	-	1
Chemical Engineering, X	46	26	22	36	-	-	130
Chemical Engineering, X-C	-	2	2	-	-	-	4
Civil Engineering, I	5	10	12	30	-	6	63
Civil Engineering, I-W (Woods Hole)	-	-	-	1	-	-	1
Electrical Engineering and Computer Science, VI							
Program 1-Electrical Science and Engineering	33	19	14	50	-	7	173
Program 3-Computer Science and Engineering	20	15	15				
Electrical Engineering and Computer Science, VI-A (Cooperative)							
Program 1-Electrical Science and Engineering	-	7	6	6	-	-	25
Program 3-Computer Science and Engineering	-	1	5				
Materials Science and Engineering, III	15	8	9	40	-	2	74
Materials Science and Engineering, III-A	-	2	1	-	-	-	3
Materials Science and Engineering, III-B (Cooperative)	7	10	10	-	-	-	27
Mechanical Engineering, II	33	20	18	35	-	5	111
Mechanical Engineering, II-A	2	4	6	-	-	-	12
Mechanical Engineering, II-B (Internship)	-	1	5	-	-	-	6
Nuclear Engineering, XXII	2	-	2	13	-	-	17
Nuclear Engineering, XXII-A (Internship)	-	-	1	-	-	-	1
Ocean Engineering, XIII	2	-	1	3	-	-	6
Naval Construction and Engineering, XIII-A	-	-	-	3	-	-	3
Ocean Systems Management, XIII-B	-	-	-	3	-	-	3
Center for Advanced Engineering Study, EN	-	-	-	-	-	1	1
Total	178	138	139	230	-	23	708
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE							
Economics, XIV	1	3	6	18	4	7	39
Humanities and Engineering, XXI-A	-	1	3	-	-	-	4
Humanities and Science, XXI-B	-	2	6	-	-	-	8
Linguistics and Philosophy, XXIV	-	-	1	19	3	-	23
Political Science, XVII	-	4	2	35	7	2	50
Political Science, XVII-A (Public Policy)	-	-	-	-	-	-	-
Psychology, IX	-	-	-	10	-	-	10
Total	1	10	18	82	14	9	134
ALFRED P. SLOAN SCHOOL OF MANAGEMENT							
Management, XV	5	6	9	78	3	11	112
Management-Fellows, XV-A	-	-	-	6	-	2	8
Management-Operations Research, XV-B	-	-	-	3	-	-	3
Total	5	6	9	87	3	13	123
SCHOOL OF SCIENCE							
Biology, VII	15	11	14	32	-	2	74
Biology, VII-A	2	3	6	-	-	-	11
Biology, VII-B	2	5	5	-	-	-	12
Biology, VII-W (Woods Hole)	-	-	-	7	-	-	7
Chemistry, V	12	13	7	47	-	3	82
Earth and Planetary Sciences, XII	2	3	8	13	2	-	28
Earth and Planetary Sciences, XII-W (Woods Hole)	-	-	-	14	-	-	14
Interdisciplinary Science Program, XXV	1	1	2	5	-	-	9
Mathematics, XVIII	6	9	11	22	2	-	50
Meteorology and Physical Oceanography, XIX	-	-	-	6	-	2	8
Meteorology and Physical Oceanography, XIX-W (Woods Hole)	-	-	-	5	-	-	5
Nutrition and Food Science, XX	-	-	-	67	-	4	71
Physics, VIII	9	-	6	29	-	-	44
Total	49	45	59	247	4	11	415
Health Sciences and Technology, HST	-	-	-	4	-	9	13
Undesignated	27						27
First Year	257						257
Grand Total	257	272	208	240	786	42	74	1,879

[1] Also included in Table III
Total undergraduate women 977; 29 special undergraduate women are included.

TABLE III-B SPECIAL STUDENTS BY SCHOOLS, COURSES AND YEARS, 1981-82 [1]

COURSE	2	3	4	G	TOTAL
SCHOOL OF ARCHITECTURE AND PLANNING					
Architecture, IV	-	1	1	6	8
Urban Studies and Planning, XI	-	-	-	28	28
Total	-	1	1	34	36
SCHOOL OF ENGINEERING					
Aeronautics and Astronautics, XVI	-	1	-	9	10
Chemical Engineering, X	-	1	-	2	3
Civil Engineering, I	-	-	-	16	16
Electrical Engineering and Computer Science, VI, VI-1, VI-3	2	1	2	77	82
Materials Science and Engineering, III	-	-	-	7	7
Mechanical Engineering, II	-	-	2	65	67
Nuclear Engineering, XXII	-	-	-	2	2
Ocean Engineering, XIII	-	-	-	1	1
Center for Advanced Engineering Study, EN	-	-	-	55	55
Total	2	3	4	234	243
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE					
Economics, XIV	-	-	-	11	11
Humanities and Science, XXI-A, XXI-B	-	-	3	-	3
Linguistics and Philosophy, XXIV	-	-	-	1	1
Political Science, XVII	-	-	1	12	13
Psychology, IX	-	-	-	-	-
Total	-	-	4	24	28
ALFRED P. SLOAN SCHOOL OF MANAGEMENT					
Management, XV, XV-A	-	-	1	40	41
SCHOOL OF SCIENCE					
Biology, VII, VII-A, VII-B	-	-	2	6	8
Chemistry, V	-	-	-	3	3
Earth and Planetary Sciences, XII	-	-	-	1	1
Interdisciplinary Science Program, XXV	-	-	-	-	-
Mathematics, XVIII	3	-	4	7	14
Meteorology and Physical Oceanography, XIX	-	-	-	4	4
Nutrition and Food Science, XX	-	-	-	5	5
Physics, VIII	-	1	-	3	4
Total	3	1	6	29	39
Health Sciences and Technology, HST	-	-	-	46	46
Undesignated	34				34
Grand Total	39	5	16	407	467

[1]Included also in Table III

TABLE IV CONTINUED, FORMER, AND NEW STUDENTS

	1977-78	1978-79	1979-80	1980-81	1981-82
CONTINUED STUDENTS					
Undergraduate and Graduate students registered at the end of the last academic year (including special students).	6,055	6,122	6,260	6,554	6,828
NON-CONTINUED STUDENTS					
Former undergraduate and graduate students who previously attended the Institute but were not registered at the end of the last academic year (including special students).	271	311	353	286	280
Undergraduate students who enrolled for the first time since secondary school (excluding special students).	1,073	1,055	1,055	1,089	1,029
Undergraduate students who enrolled for the first time at the Institute and who transferred from other collegiate institutions (excluding special students).	124	120	105	94	74
Graduate students who enrolled for the first time at the Institute (excluding special students).	968	1,025	1,011	1,077	1,033
Special undergraduate and graduate students with no previous Institute registration.	221	248	269	265	266
	8,712	8,881	9,053	9,365	9,510

TABLE V REGULAR STUDENTS FROM OTHER COLLEGES AND GRADUATES OF M.I.T. CLASSIFIED BY SCHOOLS AND COURSES 1981-82

	Entered with no previous degree	Entered with Bachelor's degree from other colleges	Entered Graduate School with Bachelor's degree from M.I.T.
SCHOOL OF ARCHITECTURE AND PLANNING			
Architecture (IV, IV-B, IV-N)	10	206	44
Urban Studies and Planning(XI, XI-N)	1	163	14
Total	11	369	58
SCHOOL OF ENGINEERING			
Aeronautics and Astronautics (XVI)	19	135	41
Chemical Engineering (X, X-C)	16	195	34
Civil Engineering (I, I-N, I-W)	13	222	25
Electrical Engineering and Computer Science (VI, VI-1, VI-3, VI-W)	91	279	288
Materials Science and Engineering (III)	2	189	46
Mechanical Engineering (II, II-A, II-B, II-T, II-W)	38	287	95
Nuclear Engineering (XXII, XXII-A)	6	133	21
Ocean Engineering (XIII, XIII-A, XIII-B, XIII-W)	6	153	14
Total	191	1,593	564
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE			
Economics (XIV, XIV-N)	5	124	3
Humanities and Engineering or Science (XXI-A, XXI-B)	2	-	-
Linguistics and Philosophy (XXIV, XXIV-N)	1	62	2
Political Science (XVII, XVII-N)	-	126	20
Psychology (IX)	-	22	9
Total	8	334	34
ALFRED P. SLOAN SCHOOL OF MANAGEMENT			
Management (XV, XV-A, XV-B, XV-N)	-	396	52
SCHOOL OF SCIENCE			
Biology (VII,VII-A, VII-B, VII-W)	9	137	8
Chemistry (V)	10	212	1
Earth and Planetary Sciences (XII, XII-N, XII-W)	2	111	11
Interdisciplinary Science Program (XXV)	-	9	2
Mathematics (XVIII, XVIII-N)	16	106	11
Meteorology and Physical Oceanography (XIX, XIX-N, XIX-W)	-	51	8
Nutrition and Food Science (XX)	-	144	16
Physics (VIII, VIII-N)	29	241	56
Total	66	1,011	113
Health Sciences and Technology (HST)	5	14	3
Undesignated	1	-	-
First Year	2		
Grand Total	284	3,717	824

TABLE VI LIST OF COLLEGES AND UNIVERSITIES WITH NUMBER OF GRADUATES ENTERING THE INSTITUTE AS REGULAR STUDENTS[1]

Abilene Christian University	1	Florida, University of	3
Air Force Institute of Technology	1	Florida Atlantic University	1
Alabama, University of, Tuscaloosa	1	Florida Institute of TEchnology	1
Albany, University of, Birmingham	1	Florida International University	1
Albion College	1	Florida State University	1
Alfred University	1	General Motors Institute	3
American University	1	George Washington University	3
Amherst College	1	Georgetown University	3
Arizona, University of	2	Georgia, University of	1
Arizona State University	2	Georgia Institute of Technology	7
Art Center College of Design	1	Georgia State University	1
Atlanta University Center	2	Goddard College	1
Auburn University	1	Grambling State University	1
Barnard College	1	Hampshire College	3
Bates College	1	Harvard University	22
Bennington College	2	Harvey Mudd College	2
Bentley College	1	Haverford College	1
Boston University	8	Hawaii, University of	5
Boston College	3	Holy Cross, College of the	1
Bowdoin College	3	Howard University	3
Brandeis University	2	Idaho, University of	1
Brigham Young University	2	Illinois, University of, Chicago Circle	1
Brooklyn College	1	Illinois, University of, Urbana-Champaign	8
Brown University	8	Illinois Institute of Technology	2
Bryn Mawr College	3	Iowa State University of Science and Technology	4
Bucknell University	3	Johns Hopkins University	4
California, University of, Berkeley	29	Juniata College	1
California, University of, Davis	4	Kalamazoo College	2
California, University of, Irvine	1	Kansas, University of	4
California, University of, Los Angeles	15	Kenyon College	1
California, University of, Riverside	1	Lafayette College	1
California, University of, San Diego	5	Lake Forest College	1
California, University of, Santa Barbara	2	Lawrence Institute of Technology	1
California, University of, Santa Cruz	3	Lawrence University	3
California Institute of Technology	15	Lehigh University	6
California State College, Stanislaus	1	Leslie College	1
California State Polytechnic University	1	Lowell, University of	3
California State University, Fullerton	1	Lynchburg College	1
California State University, Long Beach	1	Maine, University of, Orono	1
California State University, Los Angeles	1	Maritime College	2
California State University, Northridge	1	Marquette University	1
Carleton College	1	Maryland, University of, College Park	5
Carnegie-Mellon University	10	Massachusetts, University of, Amherst	8
Case Western Reserve University	2	Massachusetts, University of, Boston	3
Catholic University of America	2	Massachusetts College of Art	1
Central College	1	Massachusetts Institute of Technology	236
Central Michigan University	1	Memphis State University	2
Chicago, School of the Art Institute of	1	Miami, University of, Florida	1
Chicago, University of	6	Miami University, Ohio	3
Cincinnati, University of	5	Michigan, University of, Ann Arbor	19
City College, The	3	Michigan, University of, Dearbon	1
Claremont Men's College	1	Michigan State University	6
Clark University	1	Michigan Technological University	2
Clarkson College of Technology	1	Middlebury College	1
Cleveland State University	1	Minnesota, University of	1
Colorado, University of	5	Missouri, University of, Columbia	3
Colorado College, The	2	Missouri, University of, Rolla	2
Colorado School of Mines	1	Monmouth College	1
Colorado State University	3	Montana State University	1
Columbia University	13	Moravian College	1
Connecticut, University of	4	Mount Holyoke College	4
Cooper Union	4	Mount St. Mary's College	1
Cornell University	14	National University	2
Creighton University	1	New Hampshire, University of	1
Dartmouth College	4	New Jersey Institute of Technology	1
Delaware, University of	1	New Mexico Institute of Mining and Technology	1
Denver, University of	1	New York, State University of, Binghamton	4
DePauw University	1	New York, State University of, Buffalo	4
Detroit, University of	2	New York, State University of, Stonybrook	3
Drexel University	1	New York, State University College, New Paltz	1
Duke University	3	New York, State University College, Purchase	1
Duquesne University	1	New York Institute of Technology	1
Earlham College	1	New York Polytechnic Institute	4
Eastern Washington University	1	New York University	2
Elizabethtown College	1	North Carolina, University of, Asheville	1
Emmanuel College	1		

North Carolina, University of, Chapel Hill	1
North Carolina State University, Raleigh	4
Northeastern University	12
Northern Illinois University	2
Northwestern University	9
Notre Dame, University of	5
Oberlin College	1
Occidental College	1
Ohio State University	5
Ohio University	1
Oregon, University Of	1
Oregon State University	2
Pennsylvania, University of	11
Pennsylvania State University	10
Pepperdine University	2
Pittsburgh, University of	3
Pomona College	1
Pratt Institute	1
Princeton University	21
Puget Sound, University of	1
Purdue University	14
Rennsselaer Polytechnic Institute	10
Rhode Island School of Design	3
Rice University	3
Rochester, University of	2
Rochester Institute of Technology	2
Rutgers, The State University	4
St. Catherine College	1
St. Francis College	1
St. John Fisher College	1
St. Thomas, College of	1
St. Xavier College	1
Santa Clara, University of	1
Simmons College	1
Smith College	3
South Carolina, University of	1
Southern California, University of	3
Southern Methodist University	4
Stanford University	23
Stevens Institute of Technology	1
Stockton State College	1
Susquehanna University	1
Swarthmore College	5
Syracuse University	5
Tennessee, University of Knoxville	3
Texas, University of, Arlington	1
Texas, University of, Austin	3
Texas, University of, El Paso	1
Texas A & M University	3
Toledo, University of	1
Tri-State University	1
Tufts University	12
Tulane University	1
U. S. Air Force Academy	9
U. S. Merchant Marine Academy	1
U. S. Military Academy	8
U. S. Naval Academy	5
Union College and University	1
Utah, University of	4
Vanderbilt University	2
Vassar College	2
Vermont, University of	4
Virginia, University of	10
Virginia Polytechnic Institute and State University	3
Washington, University of	10
Washington State University	1
Washington University, Missouri	1
Webb Institute of Naval Architecture	2
Wellesley College	1
Wentworth Institute of Technology	1
Wesleyan University, Connecticut	7
West Virginia University	2
Western New England College	1
Wheaton College, Massachusetts	1
William and Mary, College of	2
Williams College	3
Wisconsin, University of, Eau Claire	1
Wisconsin, University of, Madison	7
Wisconsin, University of, Milwaukee	3
Worcester Polytechnic Institute	6
Yale University	13
U. S. Territories and Dependencies	
Puerto Rico, University of, Mayaguez	3
Total United States	1,003
Academia Poutecnica Naval (Chile)	1
Adelaide, University of (Australia)	1
Akademie der bildenden Kunste (Austria)	1
Alexandria, University of (Egypt)	1
Aristotelion Panepistimion Thessalonikis (Greece)	1
Associacao Universitaria Santa Ursula (Brazil)	1
Auckland, University of (New Zealand)	2
Australian National University (Australia)	2
Bangladesh University of Engineering and Technology (Bangladesh)	1
Beijing University (China)	1
Bombay, University of (India)	1
British Columbia, University of (Canada)	4
Calcutta, University of (India)	1
Cambridge, University of (England)	3
Canterbury, University of (New Zealand)	1
Capetown, University of (South Africa	1
Chiba Daigaku (Japan)	1
Chulalongkorn University (Thailand)	1
City University, The (England)	1
Colegio de Mexico, el (Mexico)	1
Delhi, University of (India)	1
Dublin, University of, Trinity College (Ireland)	1
Ecole Centrale de Lyon (France)	1
Ecole Centrale des Arts et Manufactures (France)	4
Ecole des Hautes Etudes Commerciales du Nord (France)	1
Ecole Nationale des Ponts et Chausssees (France)	2
Ecole Nationale des travoux Publics de l'Etat Vauex (France)	1
Ecole Nationale d'Ingenieurs de Constructions Aeronautiques (France)	2
Ecole Nationale du Genie Ruia des Aux et des Forets (France)	1
Ecole Nationale Superieure d'Architecture et des Arts Visuels (Belgium)	1
Ecole Nationale Superieure de Chime de Paris (France)	4
Ecole Nationale Superieure de l'Aeronautique et de l'Espace (France)	3
Ecole Nationale Superieure des Beau Arts (France)	1
Ecole Nationale Superieure des Mines de Paris (France)	4
Ecole Nationale Superieure de Technique Avancees (France)	3
Ecole Polytechnique (France)	1
Ecole Polytechnique Federale de Lausanne (Switzerland)	1
Ecole Superieure d'Electricite (France)	2
Eidgenossosche Technische Hochschule (Switzerland)	3
Escola de Administracao de Empresas de Sao Paulo (Brazil)	1
Escuela de Ingenieria Naval (Chile)	4
Ethnikon Metsovion Polytechneion (Greece)	9
Exeter, University of (England)	1
Hankuk University of Foreign Studies (Republic of Korea)	1
Harbin Shipbuilding Engineering College (China)	1
Ha'Technion-Machon Technologi le Israel (Israel)	1
Ha'Universita Ha'Ivrith Birushalayim (Israel)	3
Hitotsubashi University (Japan)	2
Ife, University of (Nigeria)	1
Imperial College of Science and Technology (England)	1
Indian Institute of Management (Calcutta, India)	1
Indian Institute of Science (India)	1
Indian Institute of Technology (Bombay, India)	3
Indian Institute of Technology (Khargpur, India)	2
Indian Institute of Technology (Madras, India)	5
Indian Institute of Technology (New Delhi, India)	1
Institute Nationale Polytechnique de Grenoble (France)	1
Instituto Technologico y de Estudios Superiores de Monterrey (Mexico)	2
Institutul de Constructii (Romania)	1
Istanbul Devlet Guzel Sanatlar Akademisi (Turkey)	1
Jami'at Baghdad (Iraq)	1
Keio Gijuku Daigaku (Japan)	1
Kerala, University of (India)	1
Korea Advanced Institute of Science (Republic of Korea)	3
Kyota Daigaku (Japan)	6

Lagos, University of (Nigeria)	1
Leningrad M. I. Kalinin Polytechnic Institute (U. S. S. R.)	1
Liverpool Polytechnic (England)	1
London, University of (England)	3
London School of Economics and Political Science (England)	1
Mahidol University (Thailand)	1
McGill University (Canada)	10
Melbourne, University of (Australia)	1
Monash University (Australia)	2
Mount Allison University (Canada)	1
National Central University (Taiwan, China)	1
National College of Arts (Pakistan)	1
National Taiwan University (Taiwan, China)	5
National Tsing Hua University (Taiwan, China)	5
Ned University of Engineering and Technology (Pakistan)	1
Newcastle upon the Tyne, University of (England)	5
Newfoundland, Memorial University of (Canada)	1
New South Wales, University of (Australia)	1
Orta Dogu Teknik Universitesi (Turkey)	1
Osuku Daigaku (Japan)	1
Otaru Shoka Daigaku (Japan)	1
Oxford, University of (England)	5
Pamantasan ng Philipinas (Philippines)	2
Politechnika Warszawki (Poland)	1
Pontificia Universidade de Catolica de Rio de Janeiro (Brazil)	2
Poona, University of (India)	1
Pretoria, University of (South Africa)	1
Queen's University at Kingston (Canada)	2
Rijksuniversiteit te Gent (Belgium)	1
Royal Military Academy (England)	1
Saskatchewan, University of (Canada)	1
School of Architecture (India)	2
Seoul National University (Republic of Korea)	10
Sheffield, University of (England)	1
Singapore, National University of (Singapore)	1
Sri Lanka, University of (Sri Lanka)	1
Technische Hogeschool Delft (the Netherlands)	1
Technische Universitat Graz (Austria)	1
Teknillinen Korkeakoulu (Finland)	1
Tokyo Daigaku (Japan)	9
Tokyo Kogyo Daigaku (Japan)	2
Toronto, University (Canada)	4
Tunghai (Christian) University (Taiwan, China)	1
Universidad Autonoma de Madrid (Spain)	2
Universidad Autonoma de Santo Domingo (Dominican Republic)	1
Universidad Complutense de Madrid (Spain)	2
Universidad de Buenos Aires (Argentina)	1
Universidad de los Andes (Colombia)	2
Universidad del Zulia (Venezuela)	1
Universidad Iberoamericana (Mexico)	2
Universidad Metropolitana (Venezuela)	1
Universidad Nacional Autonoma de Mexico (Mexico)	2
Universidad Nacional de Asuncion (Paraguay)	1
Universidad Nacional de Ingenieria (Peru)	1
Universidad Rafael Landivar (Guatemalo)	1
Universidad Simon Bolivar (Venezuela)	4
Universidade de Sao Paulo (Brazil)	4
Universidade Federal de Santa Catalino (Brazil)	1
Universidade Federal do Rio de Janeiro (Brazil)	1
Universita Commerciale Luigi Boccini (Italy)	1
Universita degli Studi di Florence (Italy)	1
Universita degli Studi di Pisa (Italy)	1
Universita degli Studi di Torino (Italy)	1
Universitat des Saarlandes (W. Germany)	1
Universitat zu Koln (W. Germany)	1
Universite de Paris I (France)	1
Universite de Paris IV (France)	1
Universite de Paris VI (France)	2
Universite de Paris VIII (France)	1
Universite de Paris IX (France)	1
Universite libre de Bruxelles (Belgium)	2
Universitetet I Trondheim (Norway)	1
University College, Cork (Ireland)	1
Uniwersytet Warszawski (Poland)	1
Victoria University of Manchester (England)	1
Von Karman Institute for Fluid Dynamics (Belgium)	1
Waseda Daigaku (Japan)	1
West Indies, University of (West Indies)	1
Western Australia, University of (Australia)	1
Witwatersrand, University of the (South Africa)	1
Yonsei University (Republic of Korea)	1
Total Foreign	266
Grand Total	1,269

[1]Graduates of 233 Colleges and Universities, including U. S. Territories and Dependencies in the United States and 146 Foreign Colleges and Universities.

TABLE VII GEOGRAPHIC DISTRIBUTION OF STUDENTS, 1981-82

	Under-grad.	Grad.
UNITED STATES		
Alabama	19	5
Alaska	8	1
Arizona	29	10
Arkansas	9	5
California	263	219
Colorado	48	28
Connecticut	161	74
Delaware	10	11
District of Columbia	15	23
Florida	93	41
Georgia	46	19
Hawaii	19	8
Idaho	4	3
Illinois	145	86
Indiana	30	19
Iowa	10	17
Kansas	25	8
Kentucky	17	4
Louisiana	16	10
Maine	42	13
Maryland	126	67
Massachusetts	642	1,728
Michigan	94	64
Minnesota	55	29
Mississippi	5	1
Missouri	34	15
Montana	10	3
Nebraska	19	3
Nevada	6	-
New Hampshire	38	32
New Jersey	320	112
New Mexico	8	12
New York	768	294
North Carolina	38	22
North Dakota	6	1
Ohio	123	75
Oklahoma	22	8
Oregon	38	15
Pennsylvania	219	110
Rhode Island	30	11
South Carolina	12	13
South Dakota	3	1
Tennessee	23	16
Texas	118	52
Utah	11	8
Vermont	15	11
Virginia	90	62
Washington	46	29
West Virginia	7	6
Wisconsin	60	25
Wyoming	6	1

	Under-grad.	Grad.
U. S. TERRITORIES and DEPENDENCIES		
Puerto Rico	21	14
Virgin Islands	2	-
U. S. CITIZENS		
Foreign Address	51	34
Total U, S,	4,075	3,478
FOREIGN COUNTRIES*		
Algeria	1	8
Argentina	1	20
Australia	1	15
Austria	-	4
Bangladesh	2	8
Belgium	-	18
Bolivia	2	1
Brazil	2	44
Brunei	1	-
Burma	-	1
Canada	58	107
Chile	2	16
China	6	18
Taiwan, China	25	111
Colombia	5	12
Costa Rica	-	1
Cuba	3	-
Cyprus	4	5
Czechoslovakia	-	1
Denmark	-	2
Dominican Republic	1	1
Ecuador	-	2
Egypt	3	19
El Salvador	-	1
Fiji	-	1
Finland	-	6
France	3	65
Germany	9	18
Ghana	7	5
Greece	9	72
Granada	1	-
Guatemala	1	-
Guyana	4	2
Haiti	1	1
Hong Kong	29	45
Iceland	-	2
India	31	91
Indonesia	2	7
Iran	15	41
Iraq	1	4
Ireland	1	5
Israel	3	31
Italy	3	22

	Under-grad.	Grad.
Jamaica	3	2
Japan	25	91
Jordan	-	5
Kenya	-	2
Korea	39	83
Kuwait	-	1
Lebanon	4	28
Luxembourg	-	1
Malaysia	19	25
Malawi	-	1
Mexico	5	50
Morocco	-	4
Mozambique	-	1
Nepal	1	-
Netherlands	7	7
New Zealand	-	6
Nicaragua	1	2
Nigeria	1	15
Norway	-	7
Pakistan	12	17
Panama	1	1
Paraguay	-	4
Peru	3	6
Philippines	6	11
Poland	2	6
Portugal	1	4
Rumania	-	2
Sarawak	-	1
Saudi Arabia	1	7
Singapore	10	15
Somalia	-	1
South Africa	3	10
Spain	3	19
Sri Lanka	5	7
St. Vincent	1	-
Sudan	-	2
Sweden	3	8
Switzerland	-	7
Syria	1	2
Thailand	2	11
Trinidad	8	4
Turkey	8	24
Uganda	-	1
United Kingdom	36	70
Uruguay	1	3
U. S. S. R.	-	2
Venezuela	8	30
Vietnam	11	11
Yugoslavia	1	8
Zaire, Republic of	-	1
Zambia	1	1
Stateless	17	10
Total Foreign	487	1,470
Grand Total	4,562	4,948

*Country of Citizenship

TABLE VIII NUMBER OF DEGREES AWARDED IN SEPTEMBER 1981, FEBRUARY 1982, and JUNE 1982

	S.B.			S.M.			M.Arch. M.C.P.			M.Arch. A.S.			Engineer			Ph.D.			Sc.D.			Total		
	Sept.	Feb.	June	Sept.	Feb.	June	Sept.	Feb.	June	Sept.	Feb.	June	Sept.	Feb.	June	Sept.	Feb.	June	Sept.	Feb.	June	Sept.	Feb.	June
SCHOOL OF ARCHITECTURE AND PLANNING																								
Architecture	–	–	–	–	–	–	2	10	25	3	1	1	–	–	–	–	1	–	–	–	–	5	12	26
Undesignated	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Architectural Studies	–	–	–	3	2	23	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	2	23
Art and Design	1	3	20	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	3	20
Visual Studies	–	–	–	–	5	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	6
Urban Studies and Planning	2	–	5	–	–	–	8	5	42	–	–	–	–	–	–	–	2	6	–	–	–	10	7	53
Total	3	3	26	3	7	29	10	15	67	3	1	1	–	–	–	–	3	6	–	–	–	19	29	129
SCHOOL OF ENGINEERING																								
Aeronautics and Astronautics	1	5	51	13	15	31	–	–	–	–	–	–	1	–	–	5	1	1	2	–	1	22	21	84
Ceramics	–	–	–	2	3	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	3	3
Chemical Engineering	2	8	99	4	13	14	–	–	–	–	–	–	1	1	–	–	2	2	4	5	4	11	29	119
Undesignated	–	2	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	6
Chemical Engineering Practice	–	–	–	–	12	13	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12	13
Civil Engineering	1	6	33	18	22	37	–	–	–	–	–	–	1	2	3	3	6	6	1	1	2	24	37	81
Computer Science and Engineering	7	14	93	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7	14	93
Electrical Engineering	17	27	158	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	17	27	158
Electrical Engineering and Computer Science	–	–	–	32	42	77	–	–	–	–	–	–	4	8	16	13	16	8	1	2	3	50	68	104
Materials Engineering	–	–	–	1	6	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	6	5
Materials Science	–	–	–	1	1	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	4
Materials Science and Engineering	2	11	37	–	–	–	–	–	–	–	–	–	–	–	–	4	8	5	3	5	6	9	24	48
Undesignated	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	–
Mechanical Engineering	10	10	84	26	39	51	–	–	–	–	–	–	1	1	1	2	9	8	1	2	2	40	61	146
Undesignated	–	3	13	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	13
Metallurgy	–	–	–	3	4	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	4	8
Naval Architecture and Marine Engineering	1	–	–	6	1	12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7	1	12
Nuclear Engineering	2	1	5	5	9	9	–	–	–	–	–	–	–	2	1	2	3	9	–	3	2	9	18	26
Ocean Engineering	3	–	6	6	10	11	–	–	–	–	–	–	2	1	16	–	3	1	–	–	1	11	14	35
Ocean Systems Management	–	–	–	2	4	11	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	4	11
Polymerics	–	–	–	–	2	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	4
Technology and Policy	–	–	–	4	3	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	3	8
Total	47	89	585	123	186	298	–	–	–	–	–	–	10	15	37	29	48	40	12	18	21	221	356	981

SCHOOL OF HUMANITIES AND SOCIAL SCIENCE																					
Economics	1	3	16	–	–	2	–	–	–	–	–	–	–	–	–	10	8	9	–	–	–	11	11	27
Humanities and Engineering	–	1	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	6
Humanities and Science	1	1	11	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	11
Linguistics	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	2	1	–	–	–	3	2	1
Linguistics and Philosophy	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	–
Philosophy	–	–	4	–	–	2	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	7
Political Science	1	2	12	1	3	3	–	–	–	–	–	–	–	–	–	3	6	7	–	–	–	5	11	22
Political Science:Public Policy	1	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	2
Psychology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	3	1	–	–	–	1	3	1
Total	4	7	51	1	3	7	–	–	–	–	–	–	–	–	–	17	20	19	–	–	–	22	30	77
ALFRED P. SLOAN SCHOOL OF MANAGEMENT																					
Management	1	8	22	8	10	203	–	–	–	–	–	–	–	–	–	1	6	3	–	–	–	10	24	228
SCHOOL OF SCIENCE																					
Biochemical Engineering	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–
Biology	–	–	–	1	1	1	–	–	–	–	–	–	–	–	–	4	9	1	–	–	–	5	10	2
Undesignated	–	7	21	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7	21
Chemistry	–	6	32	1	3	2	–	–	–	–	–	–	–	–	–	11	7	18	–	–	–	12	16	52
Earth and Planetary Sciences	–	2	12	1	–	5	–	–	–	–	–	–	–	–	–	3	4	5	–	–	–	4	6	22
Food Science and Technology	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
Interdisciplinary Science	–	1	4	–	4	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	5
Life Sciences	2	9	46	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	9	46
Mathematics	1	9	48	3	2	4	–	–	–	–	–	–	–	–	–	3	1	9	–	–	–	7	12	61
Metabolism and Human Nutrition	–	–	–	1	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	2
Meteorology and Physical Oceanography	–	–	–	–	1	5	–	–	–	–	–	–	–	–	–	2	4	–	–	–	–	2	5	5
Nutrition and Food Science	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	5	12	–	–	2	6	5	14
Nutrional Biochemistry and Metabolism	–	–	–	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	3	2
Oceanography	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1
Physics	3	7	72	4	5	7	–	–	–	–	–	–	–	–	–	9	10	19	–	–	4	16	22	102
Toxicology	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
Total	6	41	235	15	23	34	–	–	–	–	–	–	–	–	–	38	40	64	–	–	6	59	104	339
Health Sciences and Technology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	–	–
Management of Technology	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
Operations Research	–	–	–	3	3	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	3	4
Transportation	–	–	–	5	2	18	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	2	18
Without Course Specification	–	–	–	5	12	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	12	14
Awarded Jointly with Woods Hole Oceanographic Institution																					
Biology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	–	–
Earth and Planetary Sciences	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	3	–	–	–	–	2	3
Materials Science and Engineering	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–
Meteorology and Physical Oceanography	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	2	–	–	–	1	1	2
Ocean Engineering	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	1	1
Total	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	2	3	5	1	–	–	3	4	6
Grand Total	61	148	919	163	246	612	10	15	67	3	1	1	10	16	38	88	120	137	13	18	27	348	564	1,801

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 were established, and in 1951 the School of Industrial Management (after 1963 the Alfred P. Sloan School of Management) was added.

	Total by decade														Calendar year since 1978 (included in decade total)				
	1868-70	1871-80	1881-90	1891-1900	1901-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-80	1981-	Grand Total	1978	1979	1980	1981	1982*
SCHOOL OF ARCHITECTURE AND PLANNING[1]																			
Architecture	-	12	24	162	188	233	223	23	-	-	-	-	-	865	-	-	-	-	-
Undesignated	-	-	-	-	-	-	-	-	-	-	2	18	1	21	-	1	-	-	1
Architectural Engineering[2]	-	-	-	-	-	-	108	64	-	-	-	-	-	172	-	-	-	-	-
Art and Design	-	-	-	-	-	-	-	-	-	-	26	436	52	514	42	36	33	29	23
Urban Studies	-	-	-	-	-	-	-	-	-	-	-	156	15	171	13	14	10	10	5
Undesignated	-	-	-	-	-	-	-	-	-	-	-	2	-	2	1	-	-	-	-
Total	-	12	24	162	188	233	331	87	-	-	28	612	68	1,745	56	51	43	39	29
SCHOOL OF ENGINEERING																			
Aeronautics and Astronautics[11]	-	-	-	-	-	-	68	287	526	395	556	263	103	2,198	25	42	32	47	56
Undesignated	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-
Building Engineering and Construction	-	-	-	-	-	-	32	99	114	131	-	-	-	376	-	-	-	-	-
Chemical Engineering	-	-	-	91	123	372	571	434	740	726	421	502	206	4,186	83	95	100	99	107
Undesignated	-	-	-	-	-	-	-	-	-	-	3	91	18	112	9	13	17	10	8
Chemical Engineering Practice	-	-	-	-	-	-	99	90	95	108	1	-	-	393	-	-	-	-	-
Civil Engineering	12	84	86	256	407	504	653	284	272	457	252	499	80	3,846	65	62	62	41	39
Undesignated	-	-	-	-	-	-	-	-	-	-	7	26	1	34	1	3	1	1	-
Computer Science and Engineering	-	-	-	-	-	-	-	-	-	-	-	463	186	649	94	95	100	79	107
Electrical Engineering	-	-	72	335	349	468	1,000	719	1,218	1,518	1,941	1,857	374	9,851	138	189	172	189	185
Undesignated	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	-	1	-	-
Electrochemical Engineering[3]	-	-	-	-	28	84	133	56	-	-	-	-	-	301	-	-	-	-	-
General Engineering	-	-	-	-	-	6	226	222	230	133	-	-	-	817	-	-	-	-	-
Materials Science and Engineering[4]	-	-	-	-	-	-	-	52	194	311	186	162	80	985	10	22	36	32	48
Undesignated	-	-	-	-	-	-	-	-	-	-	1	26	7	34	3	4	1	5	2
Mechanical Engineering	5	40	147	329	502	623	797	602	1,164	1,049	563	671	213	6,705	84	129	105	119	94
Undesignated	-	-	-	-	-	-	-	-	-	-	12	143	38	193	12	16	24	22	16
Military Engineering	-	-	-	-	-	-	1	4	-	-	-	-	-	5	-	-	-	-	-
Mining Engineering and Metallurgy	8	44	64	74	250	129	174	137	-	-	-	-	-	880	-	-	-	-	-
Naval Architecture and Marine Engineering	-	-	-	43	133	69†	100	173	234	139	69	54	5	1,019	7	8	6	5	-
Nuclear Engineering	-	-	-	-	-	-	-	-	-	-	-	35	15	50	12	9	11	9	6
Ocean Engineering	-	-	-	-	-	-	-	-	-	-	-	58	17	75	2	6	10	11	6
Undesignated	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-
Sanitary Engineering	-	-	-	29	54	123	34	20	4	-	-	-	-	264	-	-	-	-	-
Total	25	168	369	1,157	1,846	2,378	3,888	3,179	4,791	4,967	4,012	4,854	1,343	32,977	545	693	678	669	674

SCHOOL OF HUMANITIES AND SOCIAL SCIENCE																			
Economics	-	-	-	-	-	-	-	-	-	-	129	260	36	425	25	23	21	17	19
Economics, Politics and Engineering or Science	-	-	-	-	-	-	-	-	61	152	100	-	-	313	-	-	-	-	-
Humanities and Engineering or Science[5]	-	-	-	-	-	-	-	-	-	49	412	323	37	821	14	18	25	18	19
Philosophy	-	-	-	-	-	-	-	-	-	-	-	37	9	46	5	2	6	5	4
Political Science[9]	-	-	-	-	-	-	-	-	-	-	114	129	26	269	8	9	8	12	14
Political Science:Public Policy	-	-	-	-	-	-	-	-	-	-	-	-	6	6	-	-	-	4	2
Total	-	-	-	-	-	-	-	-	61	201	755	749	114	1,880	52	52	60	56	58
ALFRED P. SLOAN SCHOOL OF MANAGEMENT[6]																			
Business and Engineering Administration	-	-	-	-	-	142	872	641	909	732	-	-	-	3,296	-	-	-	-	-
Management[10]	-	-	-	-	-	-	-	-	-	172	565	552	72	1,361	40	35	44	42	30
Total	-	-	-	-	-	142	872	641	909	904	565	552	72	4,657	40	35	44	42	30
SCHOOL OF SCIENCE																			
Biology[7]	-	3	11	25	27	49	57	129	74	116	16	-	-	507	-	-	-	-	-
Undesignated	-	-	-	-	-	-	-	-	-	-	-	346	62	408	24	35	36	34	28
Chemistry	2	27	80	154	151	111	141	166	232	207	307	484	85	2,147	57	62	34	47	38
Earth and PLanetary Sciences[8]	-	-	-	8	6	3	36	22	32	141	109	223	28	608	30	23	19	14	14
Undesignated	-	-	-	-	-	-	-	-	-	-	7	20	-	27	-	-	-	-	-
Food Technology and Biochemical Engineering	-	-	-	-	-	-	-	-	35	62	11	-	-	108	-	-	-	-	-
General Science or General Course	2	11	17	49	20	26	17	73	58	62	-	-	-	335	-	-	-	-	-
Interdisciplinary Science-Undesignated	-	-	-	-	-	-	-	-	-	-	-	81	6	87	5	9	6	1	5
Life Sciences[7]	-	-	-	-	-	-	-	-	-	-	291	886	109	1,286	106	72	87	54	55
Mathematics	-	-	-	-	-	-	19	48	72	220	831	867	105	2,162	74	59	45	48	57
Meteorology	-	-	-	-	-	-	-	-	56	38	-	-	-	94	-	-	-	-	-
Physics	-	5	6	24	19	21	49	170	306	617	1,079	937	157	3,390	92	91	72	78	79
Total	4	46	114	260	223	210	319	608	865	1,463	2,651	3,844	552	11,159	388	351	299	276	276
Grand Total	29	226	507	1,579	2,257	2,963	5,410	4,515	6,626	7,535	8,011	10,611	2,149	52,418	1,081	1,182	1,124	1,082	1,067

*Includes only February and June degrees
†Two received the degree in Naval Architecture, Course XIII-B, in 1916 and three in 1917
[1]See also Table XI
[2]Prior to 1923 degrees were awarded in Architecture
[3]Prior to 1909 this course was designated as Option 3 (Electrochemistry) or Physics
[4]Prior to 1938 these degrees were included in Mining Engineering and Metallurgy; changed from Metallurgy to Metallurgy and Materials Science, January 1968; changed to Materials Science and Engineering 1975
[5]Prior to 1958 these degrees were included in General Engineering and General Science or General Course
[6]Changed to Alfred P. Sloan School of Management 1963
[7]Changed to Life Sciences beginning January 1962
[8]Changed from Geology and Geophysics to Earth Sciences in February 1961, changed from Earth Sciences to Earth and Planetary Sciences in February 1970
[9]Prior to September 1965, these degrees were included in Economics, Politics and Engineering or Science
[10]Prior to 1959, Business and Engineering Administration, changed from Industrial Management to Management in February 1967
[11]Prior to 1960 Aeronautical Engineering

TABLE X NUMBER OF DEGREES OF MASTER OF SCIENCE AWARDED

	Total by decade												Calendar year since 1978 (included in decade total)				
	1886-90	1891-1900	1901-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-80	1981-	Grand Total	1978	1979	1980	1981	1982*
SCHOOL OF ARCHITECTURE AND PLANNING[1]																	
Architecture	-	8	45	31	-	-	-	-	-	-	-	84	-	-	-	-	-
Architecture Studies	-	-	-	-	-	-	-	-	-	1	39	40	-	-	1	14	25
Architectural Engineering[2]	-	-	-	-	9	10	-	-	-	-	-	19	-	-	-	-	-
Visual Studies	-	-	-	-	-	-	-	-	-	22	24	46	-	12	10	13	11
Total	-	8	45	31	9	10	-	-	-	23	63	189	-	12	11	27	36
SCHOOL OF ENGINEERING																	
Aeronautics and Astronautics[11]	-	-	-	17	59	76	307	375	645	404	96	1,979	42	36	31	50	46
Building Engineering and Construction	-	-	-	-	-	-	21	66	21	-	-	108	-	-	-	-	-
Ceramics	-	-	-	-	-	3	3	13	20	31	10	80	7	3	1	4	6
Chemical Engineering	-	3	2	18	69	152	275	467	398	280	59	1,723	36	43	26	32	27
Chemical Engineering Practice	-	-	-	-	245	284	241	256	102	285	51	1,464	31	28	29	26	25
Civil Engineering	-	1	4	27	53	179	194	350	548	738	138	2,232	73	91	85	79	59
Electrical Engineering and Computer Science (including VI-A)[12]	-	-	7	43	462	474	546	1,164	1,529	1,201	267	5,693	116	119	149	148	119
Electrochemical Engineering	-	-	-	4	16	8	-	-	-	-	-	28	-	-	-	-	-
Fuel and Gas Engineering	-	-	-	-	15	11	-	-	-	-	-	26	-	-	-	-	-
Materials Engineering	-	-	-	-	-	-	-	-	-	40	21	61	8	8	5	10	11
Materials Science	-	-	-	-	-	-	-	-	-	42	10	52	4	6	11	5	5
Mechanical Engineering	-	1	8	22	100	175	357	525	690	734	209	2,821	83	71	98	119	90
Metallurgy	-	-	-	-	8	36	92	230	205	104	22	697	12	6	11	10	12
Mining Engineering	-	-	-	9	8	16	-	-	-	-	-	33	-	-	-	-	-
Naval Architecture and Marine Engineering	-	-	2	1	5	20	60	165	281	233	36	799	24	24	20	23	13
Naval Construction and Engineering	-	-	39	48	101	89	206	-	-	-	-	483	-	-	-	-	-
Nuclear Engineering[3]	-	-	-	-	-	-	-	67	282	349	45	743	51	23	40	27	18
Ocean Engineering	-	-	-	-	-	-	-	-	3	157	36	200	17	17	15	15	21
Ocean Systems Management	-	-	-	-	-	-	-	-	-	3	22	25	-	-	3	7	15
Petroleum Engineering	-	-	-	-	-	5	-	-	-	-	-	5	-	-	-	-	-
Polymerics	-	-	-	-	-	-	-	-	-	16	11	27	2	2	7	5	6
Railroad Engineering	-	-	-	-	-	14	-	-	-	-	-	14	-	-	-	-	-
Sanitary Engineering	-	-	2	8	3	10	53	99	16	-	-	191	-	-	-	-	-
Shipping and Shipbuilding Management[13]	-	-	-	-	-	-	-	4	15	56	2	77	7	8	2	2	-
Technology and Policy	-	-	-	-	-	-	-	-	-	43	29	72	9	14	19	18	11
Textile Technology	-	-	-	-	-	1	31	34	20	11	-	97	-	-	1	-	-
Total	-	5	64	197	1,144	1,553	2,386	3,815	4,775	4,727	1,064	19,730	522	499	553	580	484

SCHOOL OF HUMANITIES AND SOCIAL SCIENCE																		
Economics[7]	–	–	–	–	–	–	–	–	19	22	2	43	3	2	1	–	2
Economics and Engineering or Science[10]	–	–	–	–	–	12	16	19	10	–	–	57	–	–	–	–	–
Linguistics	–	–	–	–	–	–	–	–	1	7	2	10	–	–	–	2	–
Philosophy	–	–	–	–	–	–	–	–	2	8	2	12	1	–	–	–	2
Political Science[7]	–	–	–	–	–	–	–	–	25	105	13	143	11	16	10	7	6
Psychology[4]	–	–	–	–	–	–	–	–	7	9	–	16	1	–	–	–	–
Total	–	–	–	–	–	12	16	19	64	151	19	281	16	18	11	9	10
ALFRED P. SLOAN SCHOOL OF MANAGEMENT[5]																		
Management[8]	–	–	–	–	4	60	122	581	1,274	1,859	429	4,329	201	203	195	216	213
SCHOOL OF SCIENCE																		
Biochemical Engineering	–	–	–	–	–	–	–	–	17	31	6	54	6	1	6	4	2
Biochemistry	–	–	–	–	–	–	–	3	6	6	–	15	1	–	1	–	–
Biology	–	1	1	10	1	19	25	29	12	44	3	145	3	–	3	1	2
Biophysics	–	–	–	–	–	–	–	2	3	3	–	8	1	–	–	–	–
Chemistry	2	3	7	22	32	51	53	46	97	69	7	389	5	5	3	2	5
Earth and Planetary Sciences	–	–	–	–	–	–	–	–	7	89	13	109	5	11	6	8	5
Food Science and Technology	–	–	–	–	–	–	–	–	57	56	7	120	7	10	7	4	3
Food Technology	–	–	–	–	–	–	12	44	3	–	–	59	–	–	–	–	–
General Science	–	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–
Geology and Geophysics[9]	–	–	2	5	21	15	17	48	71	–	–	179	–	–	–	–	–
Interdisciplinary Science	–	–	–	–	–	–	–	–	–	30	12	42	4	9	2	7	5
Mathematics	–	–	–	2	9	25	45	96	73	66	13	329	4	9	7	7	6
Metabolism and Human Nutrition	–	–	–	–	–	–	–	–	–	–	4	4	–	–	–	1	3
Meteorology and Physical Oceanography[6]	–	–	–	–	–	35	99	118	87	83	10	432	7	11	4	4	6
Neural and Endocrine Regulation	–	–	–	–	–	–	–	–	–	6	1	7	3	–	2	1	–
Nutrition	–	–	–	–	–	–	–	–	23	–	–	23	–	–	–	–	–
Nutritional Biochemistry and Metabolism	–	–	–	–	–	–	–	7	25	96	16	144	14	10	9	11	5
Oceanography	–	–	–	–	–	–	–	–	28	23	3	54	–	3	3	2	1
Physics	–	3	2	2	16	40	50	121	138	139	19	530	14	15	11	7	12
Toxicology	–	–	–	–	–	–	–	–	–	13	3	16	4	4	–	1	2
Total	2	8	12	41	79	185	301	514	647	754	117	2,660	78	88	64	60	57
Management of Technology	–	–	–	–	–	–	–	–	–	–	5	5	–	–	–	–	5
Operations Research	–	–	–	–	–	–	–	–	2	77	11	90	7	4	9	4	7
Transportation	–	–	–	–	–	–	–	–	–	4	30	34	–	–	4	10	20
Without Course Specification	–	–	–	5	308	263	123	357	299	385	51	1,791	43	41	39	25	26
Grand Total	2	21	121	274	1,544	2,083	2,948	5,286	7,061	7,980	1,789	29,109	867	865	886	931	858

*Includes only February and June degrees
[1]See Table XI
[2]Prior to 1923 degrees were awarded in Architecture
[3]Prior to 1959 included in Chemical Engineering
[4]Prior to September 1964 included in Economics, Politics and Engineering or Science
[5]Considered Engineering until 1950
[6]Considered Engineering until 1956; prior to 1981 Meteorology
[7]Prior to September 1965 included in Economics, Politics and Engineering or Science
[8]Prior to February 1967 Industrial Management
[9]Changed to Earth and Planetary Sciences beginning February 1970
[10]Includes six degrees in Political Science awarded 1965
[11]Prior to 1960 Aeronautical Engineering
[12]Changed from Electrical Engineering to Electrical Engineering and Computer Science 1975
[13]Changed from Shipping and Shipbuilding Management to Ocean Systems Management 1980

TABLE XI NUMBER OF DEGREES OF BACHELOR AND MASTER IN ARCHITECTURE AND BACHELOR AND MASTER IN CITY PLANNING AWARDED

	Total by decade								Calendar year since 1978 (included in decade total)				
	1921-30	1931-40	1941-50	1951-60	1961-70	1971-80	1981-	Grand Total	1978	1979	1980	1981	1982*
Bachelor in Architecture[2]	-	146	126	257	188	5	-	722	-	-	-	-	-
Bachelor in City Planning[1]	-	14	13	4	-	-	-	31	-	-	-	-	-
Master in Architecture[3]	63	81	78	191	214	21	-	648	-	-	-	-	-
Master in City Planning	-	18	82	114	152	317	88	771	29	49	35	41	47
Master of Architecture	-	-	-	-	23	279	61	363	30	37	27	26	35
Master of Architecture in Advanced Studies	-	-	-	-	-	193	11	204	22	24	25	9	2
Grand Total	63	259	299	566	577	815	160	2,739	81	110	87	76	84

*Includes only February and June degrees

[1]From 1935 to 1944, Bachelor of Architecture in City Planning

[2]Degree of Bachelor in Architecture changed to degree of Master of Architecture 1972

[3]Degree of Master in Architecture changed to degree of Master of Architecture in Advanced Studies in June 1972

TABLE XII NUMBER OF DEGREES OF ENGINEER AWARDED

	Total by decade					Calendar year since 1978 (included in decade total)				
	1949-60	1961-70	1971-80	1981-	Grand Total	1978	1979	1980	1981	1982*
Building Engineer[3]	5	2	-	-	7	-	-	-	-	-
Chemical Engineer	17	31	65	7	120	4	3	8	6	1
Civil Engineer	21	78	64	13	176	1	4	2	8	5
Electrical Engineer	132	444	381	52	1,009	39	24	25	28	24
Engineer in Aeronautics and Astronautics[1]	35	58	24	3	120	2	2	-	3	-
Environmental Engineer	-	-	12	1	13	1	-	1	1	-
Marine Mechanical Engineer	7	2	1	-	10	-	-	-	-	-
Materials Engineer	-	7	8	-	15	4	-	-	-	-
Mechanical Engineer	102	166	100	7	375	6	7	3	5	2
Metallurgical Engineer	24	18	7	-	49	1	-	-	-	-
Meteorologist[2]	2	-	-	-	2	-	-	-	-	-
Naval Architect	11	21	17	-	49	-	-	-	-	-
Naval Engineer	334	246	20	-	600	-	-	-	-	-
Nuclear Engineer	-	37	74	8	119	12	7	9	5	3
Ocean Engineer	-	4	199	36	239	25	18	18	19	17
Sanitary Engineer[3]	9	3	-	-	12	-	-	-	-	-
Total	699	1,117	972	127	2,915	95	65	66	75	52
Awarded jointly with Woods Hole Oceanographic Institution										
Electrical Engineer	-	-	1	-	1	-	1	-	-	-
Ocean Engineer	-	-	15	3	18	1	3	1	1	2
Grand Total	699	1,117	988	130	2,934	96	69	67	76	54

*Includes only February and June degrees

[1]Prior to 1969 Aeronautical Engineer

[2]Degree discontinued after 1955

[3]Degree discontinued after 1964

TABLE XIII NUMBER OF DEGREES OF DOCTOR OF PHILOSOPHY AWARDED

	Total by decade										Calendar year since 1978 (included in decade total)				
	1907-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-80	1981-	Grand Total	1978	1979	1980	1981	1982*
SCHOOL OF ARCHITECTURE AND PLANNING															
Architecture	-	-	-	-	-	-	-	4	3	7	1	1	1	2	1
Urban Studies and Planning[6]	-	-	-	-	-	-	24	72	22	118	7	12	10	14	8
Total	-	-	-	-	-	-	24	76	25	125	8	13	11	16	9
SCHOOL OF ENGINEERING															
Aeronautics and Astronautics[7]	-	-	-	-	-	6	57	100	16	179	8	9	11	14	2
Chemical Engineering	-	-	-	-	-	-	31	51	6	88	3	7	8	2	4
Civil Engineering	-	-	-	-	-	1	72	142	30	245	21	13	14	18	12
Electrical Engineering and Computer Science[9]	-	-	-	-	1	9	248	371	62	691	44	42	36	38	24
Materials Science and Engineering[3]	-	-	-	-	-	6	103	127	23	259	15	6	11	10	13
Mechanical Engineering	-	-	-	-	-	4	95	140	36	275	13	16	12	19	17
Nuclear Engineering	-	-	-	-	-	5	90	111	26	232	8	11	15	14	12
Ocean Engineering[8]	-	-	-	-	-	-	15	42	11	68	9	6	3	7	4
Sanitary Engineering	-	-	-	-	-	2	3	-	-	5	-	-	-	-	-
Total	-	-	-	-	1	33	714	1,084	210	2,042	121	110	110	122	88
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE															
Economics[1]	-	-	-	-	19	96	195	229	41	580	25	28	26	24	17
Group Psychology	-	-	-	-	8	1	-	-	-	9	-	-	-	-	-
Linguistics	-	-	-	-	-	-	35	68	6	109	6	3	10	3	3
Linguistics and Philosophy	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1
Philosophy	-	-	-	-	-	-	8	24	7	39	2	1	2	6	1
Political Science	-	-	-	-	-	-	71	117	24	212	12	11	11	11	13
Psychology	-	-	-	-	-	3[+]	24	49	11	87	5	2	6	7	4
Total	-	-	-	-	27	100	333	487	90	1,037	50	45	55	51	39

ALFRED P. SLOAN SCHOOL OF MANAGEMENT															
Management[2]	-	-	-	-	-	-	89	120	17	226	20	18	5	8	9
SCHOOL OF SCIENCE															
Biology	-	1	10	17	21	38	105	167	22	381	19	17	14	12	10
Chemistry	7	19	59	146	180	342	427	406	64	1,650	25	37	32	39	25
Earth and Planetary Sciences[4]	1	7	10	22	20	71	84	99	26	340	17	11	8	17	9
Mathematics	-	-	6	25	35	70	211	231	31	609	23	19	20	21	10
Meteorology and Physical Oceanography[10]	-	-	-	-	-	14	45	35	7	101	2	2	3	3	4
Nutrition and Food Science	-	-	-	-	4	28	66	156	35	289	18	23	23	18	17
Oceanography[5]	-	-	-	-	-	-	11	-	-	11	-	-	-	-	-
Physics	-	2	6	48	159	283	390	383	63	1,334	33	39	27	34	29
Total	8	29	91	258	419	846	1,339	1,477	248	4,715	137	148	127	144	104
Health Sciences and Technology	-	-	-	-	-	-	-	-	1	1	-	-	-	1	-
Awarded jointly with Woods Hole Oceanographic Institution															
Biology	-	-	-	-	-	-	-	14	2	16	3	1	4	2	-
Earth and Planetary Sciences	-	-	-	-	-	-	4	47	8	59	3	3	13	3	5
Electrical Engineering and Computer Science	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-
Meteorology and Physical Oceanography[10]	-	-	-	-	-	-	1	15	5	21	1	1	1	2	3
Ocean Engineering	-	-	-	-	-	-	-	6	-	6	2	-	-	-	-
Total	-	-	-	-	-	-	5	83	15	103	9	5	18	7	8
Grand Total	8	29	91	258	447	979	2,504	3,327	606	8,249	345	339	326	349	257

*Includes only February and June degrees
+Previously included in Industrial Economics
[1]Changed from Industrial Economics to Economics 1966
[2]Changed from Industrial Management to Management 1967
[3]Includes Ceramics; Metallurgy and Materials Science changed to Material Science and Engineering 1975
[4]Changed from Geology and Geophysics to Earth and Planetary Sciences 1970
[5]Beginning 1967-68 included in Earth and Planetary Sciences or Meteorology
[6]Changed from City and Regional Planning to Urban Studies and Planning 1969
[7]Prior to 1960 Aeronautical Engineering
[8]Changed from Naval Architecture and Marine Engineering to Ocean Engineering 1971
[9]Changed from Electrical Engineering to Electrical Engineering and Computer Science 1975
[10]Changed from Meteorology to Meteorology and Physical Oceanography 1981

TABLE XIV NUMBER OF DEGREES OF DOCTOR OF SCIENCE AWARDED

	Total by decade									Calendar year since 1978 (included in decade total)				
	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-80	1981-	Grand Total	1978	1979	1980	1981	1982*
SCHOOL OF ENGINEERING														
Aeronautics and Astronautics[1]	2	4	5	18	31	76	51	5	192	3	5	6	4	1
Chemical Engineering	-	23	78	114	117	151	77	22	582	4	7	5	13	9
Civil Engineering	-	2	12	23	46	75	45	5	208	3	1	6	2	3
Electrical Engineering and Computer Science[5]	3	12	30	34	141	124	68	14	426	3	8	6	9	5
Electrochemical Engineering	-	1	1	-	-	-	-	-	2	-	-	-	-	-
Materials Science and Engineering[6]	-	14	32	86	194	201	102	19	648	12	12	10	8	11
Mechanical Engineering	-	4	13	35	125	145	83	7	412	9	7	8	3	4
Mineral Engineering	1	-	4	-	-	-	-	-	5	-	-	-	-	-
Nuclear Engineering	-	-	-	-	9	55	55	7	126	6	4	7	2	5
Ocean Engineering[4]	-	1	-	-	2	6	12	1	22	1	1	1	-	1
Petroleum Engineering	-	-	1	-	-	-	-	-	1	-	-	-	-	-
Sanitary Engineering	-	-	2	3	18	2	-	-	25	-	-	-	-	-
Total	6	61	178	313	683	835	493	80	2,649	41	45	49	41	39
SCHOOL OF SCIENCE														
Chemistry	-	2	5	4	3	1	2	-	17	-	-	-	-	-
Earth and Planetary Sciences[2]	1	2	4	5	2	3	7	1	25	2	-	-	1	-
Mathematics	-	2	3	-	1	1	2	1	10	-	-	-	1	-
Meteorology and Physical Oceanography[7]	-	-	6	25	17	6	10	1	65	1	1	1	1	-
Nutrition and Food Science	-	-	-	3	10	17	21	4	55	2	1	1	2	2
Oceanography[3]	-	-	-	-	-	1	-	-	1	-	-	-	-	-
Physics	-	5	18	14	7	7	17	4	72	3	2	1	-	4
Total	1	11	36	51	40	36	59	11	245	8	4	3	5	6
Awarded jointly with Woods Hole Oceanographic Institution														
Earth and Planetary Sciences	-	-	-	-	-	-	1	1	2	-	-	-	1	-
Materials Science and Engineering	-	-	-	-	-	-	-	1	1	-	-	-	1	-
Meteorology and Physical Oceanography[7]	-	-	-	-	-	-	7	-	7	-	1	1	-	-
Total	-	-	-	-	-	-	8	2	10	-	1	1	2	-
Grand Total	7	72	214	364	723	871	560	93	2,904	49	50	53	48	45

*Includes only February and June degrees
[1]Prior to 1960 Aeronautical Engineering
[2]Changed from Geology and Geophysics to Earth and Planetary Sciences 1970
[3]Beginning 1967-68 included in Earth and Planetary Sciences or Meteorology and Physical Oceanography
[4]Changed from Naval Architecture and Marine Engineering to Ocean Engineering 1970
[5]Changed from Electrical Engineering to Electrical Engineering and Computer Science 1975
[6]Changed from Metallurgy and Materials Science to Materials Science and Engineering 1975
[7]Changed from Meteorology to Meteorology and Physical Oceanography 1981

TABLE XV SUMMARY OF DEGREES AWARDED

(1868-1982)

Bachelor in Architecture (discontinued 1972)	722
Bachelor in City Planning (discontinued 1954)	31
Bachelor of Science	52,418
Master in Architecture (discontinued 1972)	648
Master in City Planning	761
Master in Public Health (discontinued 1944)	104
Master of Architecture	363
Master of Architecture in Advanced Studies	204
Master of Science	29,109
Advanced Engineering	2,915
Advanced Engineering awarded jointly with Woods Hole Oceanographic Institution	20
Doctor of Engineering (discontinued 1918)*	4
Doctor of Philosophy	8,146
Doctor of Philosophy awarded jointly with Woods Hole Oceanographic Institution	103
Doctor of Public Health (discontinued 1944)*	9
Doctor of Science	2,894
Doctor of Science awarded jointly with Woods Hole Oceanographic Institution	10
	98,461

*See 1959 Report of the Registrar for details

WARREN D. WELLS

Vice President in the Office of the President

The activities of the past year are reported in the following pages by each of the managers of the areas for which I am responsible. These areas include: Affirmative Action, Campus Information Services, Career Planning and Placement, the Dean for Student Affairs Office, the Department of Athletics, the MIT Press, the News Office, the Office of Admissions, the Personnel Office, and the Quarter Century Club.

Last year we made a major effort to introduce strategic planning and a systematic approach to setting long-range goals, program priorities, and program budgeting for the services we provide in support of the MIT Community and the Institute's academic program. I would like to comment here on our efforts in this regard and on the significance of planning for the future.

In the fall of 1981, each of the managers in our areas prepared a statement of mission and program objectives, and a set of action strategies, ranked in order of priority. These statements were the result of intensive planning efforts in which we treated each of our service areas as a strategic unit of the Institute. The central purpose of the exercise was to find creative ways to maximize the quality of services we provide within existing resources.

In the winter and spring of 1982, we participated in the Institute-wide effort at task-oriented budgeting (TOB). For our areas the objective of TOB was twofold: first, to enter the budgeting phase of strategic planning by applying the available fiscal, human, and physical resources to the substantive program priorities established in the fall; and second, to prepare specific plans, based on review and reorientation of program priorities, that would result in three budget levels. These were the fiscal year 1982 funding level, 95 percent of the fiscal year 1982 level, and 80 percent of the fiscal year 1982 level. We prepared these plans at three levels of funding in order to begin to explore the impact on our programs and services of significant funding reductions which appeared to be in prospect for the next three years.

In fact, on June 1 of this year, each vice president was asked to submit fiscal year 1983 budgets with a five percent reduction from fiscal year 1982 levels, and to plan for further reductions (on the order of 10 to 15 percent) to be applied to Institute administration and support services in the next two years.

I recount our successive steps and efforts in some detail here in order to make an important point about the planning process and its relation to budgeting. In my view, the continuity and the order of planning -- from goal setting to strategic programming (and setting of substantive program priorities), and then to budgeting (and to the making of specific financial or staffing decisions) -- are essential to achieving success in the strategic management of MIT operations, including academic programs and support services. When questions of financial restrictions and issues of fiscal control enter the planning process too early, it is almost guaranteed that they will dominate decisions to the point that some creative approaches and solutions will not have a chance to surface or receive adequate attention on the basis of their substantive merit. Moreover, if serious fiscal restrictions are in prospect, there should be an opportunity to reconsider substantive goals, programs, and priorities, to see if and how they should be adjusted or reorganized, before taking specific actions to eliminate jobs or reduce operating expenses.

The seeds of the planning process for our areas were sown in the summer of 1981. The steps of the process were designed in group discussions of the Vice President's Staff Group, consisting of the managers that report to me and the senior staff associates in our Office. Each manager was expected to involve his or her staff in the planning activities within each unit. At each major step of the way, each manager reviewed with me the approach and plans developed.

The style, timing, and form of this intensive and iterative process varied considerably across the several areas. There is much room for such variation to accommodate the nature of the

activities, organization, and working style of individual managers. But there are a few basic premises that must be adhered to, in my view, in order to made the process reliable and successful. First, it is essential to have the primary planning responsibility and initiative rest with the managers, who are also responsible for implementation of their plans. Second, it helps enormously to set in motion a cooperative process in which all staff members have an opportunity to contribute at every step of the way, in order to achieve the understanding and commitment necessary to support and carry out the plans. Third, there should be adequate opportunity for the senior officer, and managers of related areas whenever possible, to know about and influence the substantive plans and priorities at the policy level, without second-guessing each manager's judgment in the specifics of his or her work and without interfering with each manager's responsibility in the implementation of the plans. If these three objectives are achieved, the manner and form of the planning process may vary to suit individual circumstances.

It is very gratifying to look back at the year's efforts in laying the foundations of a long-range planning approach to the management of services at MIT. The credit for success goes to everyone who participated and contributed to the development of the process. In the next two years the strategic management system we have been developing will be put to a serious test as we proceed to retrench financially at a time when there is growing demand for support and services to people throughout MIT.

CONSTANTINE B. SIMONIDES

Affirmative Action Program

Major activites of the Equal Opportunity Office (EEO) for the past year have centered on maintenance of the Institute's internally defined priorities concerning equal opportunity and affirmative action. In the climate of retrenchment that characterizes governance at all levels and that certainly affects institutions of higher education, it is becoming fashionable to ignore many of the equal opportunity imperatives of the recent past. Within the Institute, however, the Equal Opportunity Staff Group, formed last year in part to better coordinate our EEO efforts, has continued to focus attention on important EEO issues and concerns. Continued examination by the Equal Opportunity Committee of MIT's equal opportunity performance also has contributed significantly to the maintenance of positive internal pressure for EEO/Affirmative Action concerns.

Other activities have included a successful application to the Xerox Corporation for the awarding of a Kurzweil Reading Machine for the visually impaired. To be housed in the Student Center Library, this machine will be available for use by the Institute's visually handicapped students, by sight-impaired students and members of the general community in the greater Cambridge area, and by a number of MIT researchers. The addition of this device to our inventory enhances MIT services in support of handicapped members of the community.

Finally, a significant staff change has occurred recently. As of July 1, 1982, Dr. Patricia Bell-Scott will become the Institute's new Assistant Equal Opportunity Officer, culminating a nationwide search begun last December. We welcome Dr. Bell-Scott to MIT and extend best wishes for continued success.

ISAAC M. COLBERT

Campus Information Services

The past year was characterized by the development of better coordination among the various offices within the Campus Information Services (CIS) -- the Communications Office, the Office of Design Services, and the Information Center -- so that through a team approach we have been

able to offer fuller service. This team approach was used in providing organizational and communications support to activities as diverse as student recruitment, support for international staff, building dedications, Commencement, conferences, and other special events.

Several administrative changes have facilitated this team approach to services provided by the CIS: Janet Snover, previously editor/production manager of the MIT Bulletin, was promoted to communications manager and head of the Communications Office within CIS; the Office of Special Events, headed by Gayle Fitzgerald, was consolidated with the Information Center (organizationally, if not yet physically); and Virginia Lyons was promoted to assistant director of the Information Center, with continuing special responsibility for international staff and visitors.

In addition to these developments within CIS, there have been increased coordination and communication among those offices and activities serving MIT's international community, including the International Visitor's Office in the Information Center. Following a review conducted by Robert Weatherall at the request of the Academic Council, an "international council" convened by Dr. Louis Menand III, special assistant to the Provost, has begun meeting on a regular basis to share information and consult on issues or problems which cut across more than one organizational area.

For the coming year, our major goals are to make the services of CIS better known and continue to build a team approach to providing information services; to review and improve communications to visitors and prospective students, in conjunction with various other offices having responsibility in this area; and to strengthen the connections between our planning and budgeting efforts, so that the quality and effectiveness of our services are maintained during a period of financial stringency for the Institute.

In the following pages are the reports of each of the offices within the Campus Information Services: the Communications Office, the Office of Design Services, and the Information Center.

Communications Office

In the fall 1981 the name of the Bulletin Office was changed to the Communications Office, Campus Information Services. This change was made to recognize and formalize the expanded publications role of the Office and its staff. The change will also help to strengthen the team approach to services within CIS. Janet Snover, formerly editor/production manager of the Bulletin, was promoted to communications manager of the new Office.

The Communications Office will continue to be responsible for the production of the publications it has handled in the past. These include the *Courses and Degree Programs* catalogue, the *Summer Session Catalogue,* the *Student Directory,* and the small and large versions of both the *Report of the President* and the *Report of the Treasurer.* In addition, the Office provides editorial and production services and advice to other areas within CIS as well as to other parts of the Institute. Some examples of this assistance within CIS included work on *A Factual Profile,* the Commencement program, Killian Lecture materials, Awards Convocation copy, symposia and facility dedication materials, and a 12-page supplement of committee listings in *Tech Talk.*

At the request of the Dean for Student Affairs, the Communications Office reviewed the 40 publications produced by the Dean's Office, and made recommendations regarding writing style, content, design, production methods, and costs. The Office also assisted the Dean's Office in editing manuscripts for a booklet on drugs and another about human relationships which the Dean's Office will publish for MIT students.

The Office assisted Admissions in the editing of their three recruitment publications aimed at women, black, and Mexican-American students. These publications will be designed and produced by Design Services. The Office also worked on copy for the Admissions viewbook, *MIT Today.* In addition, Ms. Snover and her assistant, Mark Wilson, provided editorial and production services to the Analytical Studies and Planning Group, the Personnel Office, and a number of academic departments.

In the fall, Ms. Snover gave a Publications Production Workshop as part of the Personnel Development Program. The workshop was planned for MIT employees who handle publications as an extra part of their jobs. The workshop provided a brief overview of the steps and processes used in producing

a printed report, brochure, or catalogue. The program covered some of the terminology and jargon of typesetting, printing, and paper, with the aim of making participants more comfortable and confident in dealing with writers, designers, typesetters, and printers. In the second part of the workshop, publications professionals from MIT's Design Services, Graphic Arts, and the Engineering Word Processing Center familiarized the class with their services and offered suggestions about ways to work most effectively with their offices.

During the year, Ms. Snover served as a member of MIT's Long-Range Office Automation Planning Committee. Outside of MIT, she was an Executive Board member of the Council for the Advancement and Support of Education for District One, and served as cochair of its awards committee.

Design Services

The Office of Design Services, under the direction of Jacqueline Casey, continues to support the communications efforts of MIT by designing and managing the production of publications for departments and offices throughout the Institute. Among the areas receiving major assistance from the Office during the past year were the Admissions Office; the Corporation; the Committee on the Visual Arts; Resource Development; a variety of programs in the School of Architecture and Planning, the School of Engineering, and the Sloan School of Management; the Special Summer Programs; and a wide range of special events and conferences coordinated by the Information Center. As in the past, the Office provided major design and production support for the communications program of the Alumni Association, including design direction for *Technology Review*. Overall, the Office undertook 361 graphic design and publishing projects during 1981-82.

In November, Mario Furtado, production manager for the Alumni Association publications, left the Institute to work for a design studio in Boston. He was succeeded in that position by Dorothea Black.

A highlight of the past year was the awarding to MIT of the Design Leadership Award of the American Institute of Graphic Arts, in recognition of the excellence in design demonstrated by MIT over the year. This award was given in recognition of design leadership provided by Design Services, the MIT Press, and the Visible Language Workshop.

Professional recognition was accorded to the design efforts of the Office in other ways as well. The work of Ms. Casey, Nancy Cahners, Ralph Coburn, and Betsy Hacker was broadly represented in major design exhibits, books, and journals. These include a special article on MIT design in the Swiss magazine *Graphis*. The work of Ms. Casey and Mr. Coburn was represented in the 1982 New York Type Directors Show. MIT Design Services work was displayed at Coker College in Hartsville, South Carolina, and the Boston Art Directors Club awarded the Office 10 distinctive merits: Cahners (6), Casey (2), Hacker (2) and a total of 6 merit awards: Cahners (3), Casey (2), and Coburn (1).

A second poster by Ms. Casey was acquired for the permanent collection by the Museum of Modern Art in New York. Her work also was displayed at the University of Louisville Poster Exhibition. In addition, Ms. Casey served on a search committee for two faculty members at the Yale University School of Art.

Information Center

The Information Center provides service in three major areas: public relations and information dissemination; coordination of major Institute events and conferences; and support for international faculty, staff, and visitors.

The public relations and information services of the Center include gathering and giving information to members of the MIT community as well as to visitors, compiling information for the MIT planning calendar, managing the guided tours of the campus, updating the Institute map and visitors guide, maintaining the general Institute mailing lists, identifying and forwarding Institute mail that has been addressed generally to MIT, and maintaining records and publishing a *Tech Talk* supplement of the Institute committees.

The following is a general list of materials distributed from the Center:

Catalogue Issues	16,351
Reports	2,784
MIT maps & guides	29,937
Other publications	26,737

The guided tours, conducted primarily for prospective students and their families, remain an important public relations function of the Institute, with an almost 15 percent increase in the number of visitors taking tours this past year. The 17 student guides are a candid, cordial, and informative group, diligently supervised by head guides Susan Krolewski, graduate student, and Shih-Chii Liu, Class of 1983. During the summer months, the Center was most fortunate in having as guides Ms. Liu and Eric Zankman, Class of 1983, during the most hectic time for visitors. Included in the visitor program this year, for the first time, is a film entitled "MIT Today," shown daily before the tours.

The following is a list of visitors to the MIT campus who took tours this past year:

Prospective students	2,567
International students	939
General visitors	4,242
Total	7,748
Visitors on special tours	924
Visitors on general tours	6,824
Total	7,748

Geoffrey Frank, Class of 1983, served as coordinator for Lobby 7 this past year. Susan Laing of the Committee on the Visual Arts will be the coordinator for the coming year. This will provide increased continuity for the planning and organization of events and exhibits in the lobby, particularly during the summer months.

There were many special events and conferences coordinated by the Information Center this past year, activities enhanced by the consolidation of the Office of Special Events with the Center. The assistant for special events, Gayle M. Fitzgerald, now reports to Mary L. Morrissey, director of the Center. This organizational shift has enabled Ms. Fitzgerald to assist the director on the coordination of many special events for the MIT community, in addition to her work as logistical coordinator for on-campus meetings of professional societies and other groups.

During this past year, this section of the Center provided assistance in the planning and coordination of eight major research reviews or conferences held on the campus: The Annual Symposium of the Mutual UFO Network; the Northeast American Society for Eighteenth Century Studies Conference on "Science, Myth, and Knowledge"; the Conference on CAD/CAM Technology in Mechanical Engineering; the meeting of the Association of Affirmative Action Professionals; the Power Electronics Specialists Conference; the American Society of Heat, Refrigeration, and Air-Conditioning Conference; the Conference of the American Humanist Association; and the First National Conference on Issues Facing Black Administrators at Predominantly White Colleges and Universities. Planning also continued for several major conferences scheduled for 1982-83.

During the fall semester of 1981 and spring semester of 1982, the section made arrangements for 58 presentations by companies visiting the campus in association with the Office of Career Planning and Placement.

In September 1981, Sarah J. Clere joined the Office for Special Events as senior secretary and has provided invaluable support to the many conferences and various Institute special events.

The director was directly involved in planning many special events, but the most exciting event each year, one involving almost the entire MIT community, is Commencement. This year, despite cloudy skies and drenching rainy days before, there was a respite on this special day as 6,500 family members and friends watched 1,562 graduating students receive 1,623 degrees. Katherine

Graham, chairman and chief executive officer of the Washington Post Company, was the first speaker from outside MIT to address the graduates in 19 years. Professor Roy Lamson and the Intermission Trio again gladly donated their time and effort to play at the reception immediately following the exercises. This year, more than 90 children from infancy to school age were cared for at the Child Care Center during Commencement exercises.

The International Visitors section of the Information Center had an extremely busy year, ably managed by Virgina Lyons who was promoted during the year to assistant director of the Center. The number of international staff and faculty at MIT increased to a total of 1,092, and the section provided advice and assistance in a large number of temporary visa and immigration cases. The following cases for permanent residence were handled during the year: 20 individual labor certifications, one blanket labor certification, and 20 preference petitions. An extraordinarily large number of temporary H-1 visas -- 54 new petitions and 47 extensions -- were prepared for faculty and staff by Lillian Whelpley, administrator in the Center.

Ms. Lyons continued to work on governmental issues affecting immigration and labor regulations, with colleagues at MIT, at other universities, and in the government. For example, during the year Congressman Barney Frank introduced a bill to amend the Immigration and Nationality Act to give foreign researchers the same labor certification requirements as foreign faculty members. The bill was the result of MIT's contact with Congressman Frank regarding MIT's concern that researchers be evaluated in the same way as college and university teachers for labor certification purposes.

Another issue having the potential for a large impact on MIT as an international university is a comprehensive immigration bill which would affect the ability of foreign students and staff to remain in the United States. This bill, sponsored by Senator Alan Simpson and Congressman Romano Mazzoli, was introduced in the House and the Senate in the spring of 1982.

The Provost wrote to Senator Strom Thurmond, chairman of the Senate Judiciary Committee, about MIT's concern regarding the sections of the bill which would prevent foreign students from staying in the US and make it more difficult to immigrate. The bill's progress is being monitored, and other institutions have been informed of MIT's position to try to increase institutional response to the provisions giving us concern.

In December 1981, Ms. Lyons assumed additional responsibilities as secretary of the Committee on International Institutional Commitments, working closely with the chairman, Professor Walter A. Rosenblith, the Committee members, and the Office of Sponsored Programs. As chair-elect of the New England region on the National Association for Foreign Student Affairs during 1981-82, Ms. Lyons was involved in planning the regional conference and an immigration workshop, and she participated at the Regional Council briefing in Washington. She was also a panelist and session chair at the National Conference in Seattle.

This report would not be complete without a salute to the Information Center staff, all of whom undertake the various tasks assigned with a sense of personal and professional commitment. Ms. Fitzgerald has very ably and efficiently continued her role as conference coordinator. Ms. Lyons has continued her efficient, competent, and effective role in advising international faculty and staff in immigration and visa matters. Ms. Whelpley very ably handles many varied projects in the administration of the Center and in support of international visitors. And without the teamwork of Kathleen Barrett, Ms. Clere, Constance Cunningham, Donald Ferland, and Terri Priest, who all extended themselves and divided their time to whatever area was in need, the Center could not operate at the level of service the Institute has come to expect.

KATHRYN W. LOMBARDI

Career Planning and Placement Office

The employment outlook for students graduating 1981-82 was as full of contradiction as was the economy as a whole. In spite of the recession, the number of employers coming to the Office to

recruit was the largest on record -- 450 compared to 406 in 1980-81. Nevertheless, a number of students in some disciplines were without jobs at graduation. It was a frustrating year for some, but not all, students in architecture, chemical and civil engineering, geology, political science, and urban studies. In civil engineering, for example, students in structures generally fared well, while students in water resources fared badly. Students in chemical engineering did well if they interviewed early in the year. The oil industry was hungry for engineers in the fall and helped to bid up salaries sharply. Offers to bachelor's degree candidates in chemical engineering rose 12 percent over the year before; offers to master's degree candidates rose more than 15 percent, and offers to Ph.D. candidates jumped 23 percent. But the industry reversed its hiring plans during the winter and made a minimum of offers in the spring.

In the fall, oil firms were still expressing concern about how they would find enough engineers to design and run the massive projects they expected to build during the 1980s, and were seeking advice on how to strengthen their recruiting. Softening prices for oil and the continuing high cost of money pushed these concerns aside. At the end of the academic year a major firm which sells to the oil industry wrote as follows to explain its cutbacks in hiring:

> "The downturn in oil field activity has been longer and more serious than ever before. The extent of the business decline was not predicted within the industry. The many factors that are contributing to this unprecedented decline continue to create uncertainty as to when and to what extent a turnaround will occur."

The dislocation in the oil industry is a particularly vivid example of the sort of dislocation which has haunted many well-argued projections of the need for scientists and engineers. A student's training in a technical discipline is a perishable commodity, and students have reason to shy away from fields in which they may not be able to employ their expertise immediately, however promising the long-term demand may be. This year's cutbacks in technical hiring are likely to promote shortages of talent in the fields concerned in another few years.

The underlying demand for technical people, which we can expect to see when the economy recovers, is very strong. Over 550 employers confirmed recruiting dates with us initially this year -- more than we could have accomodated if they had all come. While many firms in the electronics industry reduced their hiring, other firms recruited energetically. They sought students in a range of disciplines, not only in electrical engineering. Mechanical engineers, for example, were in strong demand, and in spite of the fact that many industries identified with mechanical engineering -- automobile, farm machinery, machine tool, lumber, and paper -- were in disarray, salaries in mechanical engineering kept pace with salaries in electrical engineering. Mechanical engineers have a central part to play in the growing effort to increase productivity and product quality by improving manufacturing methods.

Students responded to the cloudy job market by making active use of the Office. A total of 1,556 students and postdoctoral candidates had 10,004 interview with visiting employers. The number of interviews is the highest in the history of the Office. Eight hundred and twenty-seven students, also a record, submitted résumés for the Science and Engineering Résumé Book. A large number of those having interviews, as well as many other students consulted with the counseling staff on questions related to career choice, possible employers, or job hunting strategy. The number of alumni using the Office rose to 419 from 356 the year before. The Office has made a special effort to help students in architecture, political science, and urban studies -- fields in which employers expect job candidates to seek them out, and in which reductions in government spending have reduced employment opportunities significantly.

Slightly more than half the students using the Office are undergraduates. The heavy traffic in the Office last year, therefore, does not by itself indicate that more graduating seniors are choosing paid employment over graduate school. Conversations with undergraduates, however, suggest that the lure of a paid job continues to be very strong. In 1979-80 and again in 1980-81 the percentage of seniors going directly to graduate school was down 45 percent, after dropping to 51 percent in 1977-78 and 1978-79. During the previous 16 years it rarely fell below 60 percent. The percentage has not been below 48 percent since 1957-58. Part of the decline can be accounted for by the swing of students into engineering and away from science, but the popularity of graduate school with engineering seniors has also dropped from nearly 56 percent in 1975-76 to 42 percent in 1977-78 and 1978-79 and to 37 percent in 1979-80 and 1980-81. Unfortunately, graduate education is not necessarily as rewarding an experience, in economic terms, as it used to be.

In 1969-70, when twice as many United States students earned doctoral degrees in engineering as today, a graduating Ph.D. in electrical engineering, for example, earned 1.7 times the salary of a graduating senior. In 1980-81 the ratio was less than 1.4. This year, however, the reward for having a graduate degree increased faster in several disciplines than the starting pay for a graduating senior, and we may begin to see more seniors thinking seriously of graduate school. During the past year we cooperated with the Consortium on Financing Higher Education in designing and mailing a questionnaire to elicit from seniors information on the financial factors affecting their decision to go or not to go to graduate school. We look forward to seeing an analysis of the returns from students at MIT and other colleges in the consortium.

ROBERT K. WEATHERALL

Dean for Student Affairs

INTRODUCTION

During the 1981-82 academic year, the Office of the Dean for Student Affairs (ODSA) continued to engage in a variety of activities designed to carry out its overall goal of supporting and complementing the academic program of the Institute and to achieve the broad objectives of assisting in the development of good citizens, promoting a healthy living environment, supporting the personal growth and development of individuals, and of assisting students in the transition from a dependent environment to an independent one.

Several activities also addressed the following priorities established by the Office for 1981-82: 1) the building of stronger ties with the faculty and academic departments and better utilization of our various advisory groups, 2) improved planning and delivery of services to graduate students, and 3) increased attention to the quality of the total undergraduate experience at MIT for all students.

While the report which follows contains details on many of these activities, it should be stressed here that, in our efforts to achieve the first priority, ODSA staff served on most of the major faculty and Institute committees, worked closely with the faculty residents, the Committee on Student Affairs, and the Committee on Educational Policy, and interacted frequently with individual faculty and faculty advisors which resulted in a significant improvement in our working relationship with the faculty. Working closely with many faculty and students, I believe that our Office was able to provide useful assistance in academic decision making and undergraduate course evaluations, and improvement of teaching.

In addition to strengthening ties with the faculty and the academic program, each section of the Office made special efforts to improve the delivery of services to graduate students, our second priority. These efforts included advising the house governments and community associations of the four on-campus graduate houses, working with the Graduate Student Council on such issues as the availability of housing for graduate students and the implementation of recommendations contained in the 1978 Dober Report on graduate student life, assisting in the preparation of a booklet for graduate teaching assistants, and maintaining significant and sustained contact with graduate women in several departments. Three members of the staff also served on the Administrative Housing Group which met on an almost weekly basis throughout the year primarily to address the issue of graduate student housing. The group developed major policy papers on pricing, capacity, and on tenure and access as well as recommendations on how the Institute should proceed in meeting our long-range graduate housing needs.

Efforts to improve the quality of life for undergraduates, our third priority, included the opening of the new 352-bed facility at 500 Memorial Drive which eliminates previous crowding problems and permits the accomodation of transfer and readmitted students in the housing system for the first time; the resolution of the East Campus/Senior House dining issue by the decision to install kitchens in these two dormitories; the initiation of a series of luncheon and dinner meetings on leadership, accountability, and other issues related to student activities; the conduct of special

seminars on leadership development, time management, and study skills; and a series of special programs and staff visits to Institute Houses and Independent Living Groups. In this area of our work, remarkable initiative, imagination, and hard work were demonstrated on the part of many students who saw challenges and responded with characterictic MIT enthusiasm and enterprise.

In addition to addressing these external priorities, our staff engaged in a number of internal activities that resulted in a greater sense of unity and cohesion and served to minimize the stress associated with mandatory budget reductions. Paramount among these activities was a year-long strategic planning process in which this Office and others reporting to Vice President Constantine Simonides were engaged. The purpose of this effort was to develop a long-term view of our goals and to place the educational and service functions -- which are the reason for our existence -- at the heart of our activities (programs) and our decisions with regard to resources (budget). This process resulted in the systematic development of objectives and program priorities and allowed for a smooth, though somewhat painful, adjustment to the five percent budget cut this Office must absorb in 1982-83. We have no illusions about accomplishing more with less; but the careful planning process and the wide base of consultations have at least assured us that we can continue to do our most important functions well.

Other major internal activities included 1) a series of meetings on the proposed merger of the residence programs and student activities sections of the Office made necessary by stringent budget guidelines for the next three years; 2) a complete revision and updating of all OSDA job descriptions; 3) a year-long series of special staff and staff development activities including several discussions on ethical issues in student affairs, invited guests at staff meetings, and staff attendance and participation in a number of local, regional, and national meetings on student affairs and higher education issues; and 4) a day-long OSDA planning and evaluation meeting held at Endicott House on June 9 at which we reviewed our 1981-82 activities and outlined our plans for the 1982-83 academic year.

Our staff was significantly strengthened and stabilized this past year by the addition of Professor Jeffrey Meldman of the Sloan School as Associate Dean for Student Affairs and of Assistant Deans Linda Vaughan and Jeannette Gerzon. Dean Meldman filled a vacant half-time faculty position and Deans Vaughan and Gerzon replaced Deans Kellermann and Houpt who left the staff during the 1980-81 academic year. Additional strength resulted from nine members of the OSDA staff enrolling in special classes offered by the Institute or in degree programs at local universities, and we were heartened by the expression of appreciation for service accorded to our own Dean Robert J. Holden who received the prestigious Billard Award this past year.

Overall, we had another productive year, thanks to a dedicated and talented staff, to considerable support from our major advisory groups, and to substantial cooperation from students, student groups, faculty, staff, and offices throughout the Institute.

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. Activities this past year within the major UAS programs are described below.

Freshman Advising Program

The freshman advising program, in substance, was the same as that described in the 1980-81 report. The primary counseling of freshmen during 1981-82 was carried out by 247 advisors (127 faculty, 86 staff, 16 lecturers/instructors, and 18 graduate students). These advisors were supported by undergraduates serving as "associate advisors."

The experimental Baker House advising program, which matched seven freshman advisors with approximately 35 freshman in Baker House, continued for a third year. The advisees were especially positive about the informal availability of associate advisors in their living group.

Thirteen freshmen withdrew for a variety of personal reasons during academic year 1981-82. Eight 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, for freshman, 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.

Academic Year	Required Withdrawals	CAP Warnings	UAS Letters
1981-82	8	93	98
1980-81	11	104	121
1979-80	16	106	93
1978-79	13	108	87

This past year, Dean Holliday Heine participated in discussions conducted by the Committee on Educational Policy on several matters that related to freshman advising. In the fall, the Committee considered the question of a possible correlation between overloading in the second term of the freshman year and poor performance in the sophomore year. UAS carried out a study for them disproving that connection. In the spring, the Committee examined alternative ways to evaluate the performance of freshmen within the context of the pass/fail system. Our discussions with them helped develop a compromise position which will be debated by faculty and students in the fall of 1982.

Undesignated Sophomore Advising Program

The number of students choosing not to declare a major for some portion of their sophomore year decreased again this past year, while the number of advisors increased.

Thirty-five volunteer advisors drawn from faculty and staff were needed to provide a reasonable match of interests with 62 undesignated sophomores at the beginning of the fall semester and 24 in the spring. The respective student figures for 1980-81 were 71 and 39 for the fall and spring terms. These students were assisted by 29 volunteer advisors that year.

Preprofessional Advising and Education

The Preprofessional Advising and Education component of UAS under the new leadership of Assistant Dean Jeannette Gerzon continued to serve as a focal point for students interested in careers in medicine, law, or allied fields. During the past several years, the number of undergraduate applicants to medical school who were successful in gaining admission has ranged between 83 and 88 percent. This past year, 33 alumni and 11 graduate students applied to medical school, representing a slightly higher number of such applicants than in previous years.

Nineteen undergraduate students and 19 alumni applied to law school for the 1982 entering class. In 1981, there were 55 applicants in total, 52 of whom were admitted.

Three new advisors were added to the Premedical Advisory Council which continues to counsel and assist students in considering and applying to medical school. In addition, support continues to be provided by members of the Committee on Preprofessional Advising and Education and the Prelaw Advisory Council.

Administrative Support to the Committee on Academic Performance

The Committee on Academic Performance (CAP) was chaired this past year by Professor Judson Baron. During the 1981-82 academic year, the CAP handled approximately 450 petitions from individual students requesting readmission and exceptions to certain regulations of the faculty. For the academic year 1981-82, the Committee voted a total of 84 required withdrawals and 396 warnings, representing .92 percent and 4.3 percent respectively of the students reviewed.

A 10-year summary of the CAP's end-of-term actions was prepared early in the 1981-82 academic year. With data from the Registrar, the chairman also compiled extensive statistical information on students with warnings and required withdrawals, particularly concerning the success rate of students returning from a required withdrawal. A more thorough review of this information will be carried out during the 1982-83 academic year.

Undergraduate Seminar Program

The number of seminars offered through the Undergraduate Seminar Program in the fall term decreased by one in comparison with the previous fall's figures (54 to 53) while comparable offerings during the spring term showed an increase from 37 to 42. Approximately 1,270 students (of whom 753 were freshmen) participated in seminars this past year, indicating significant student interest. Professor Michael Driscoll served his final year as faculty chairman of the Undergraduate Seminar Program. Professor Jeffrey Meldman will serve as chairman during the coming year with Peggy Richardson continuing to serve as executive officer of the program.

Academic Support and Information Center

The primary objectives of this area are to encourage a strong undergraduate support system for the benefit of both students and faculty advisors and to undertake or support efforts designed to improve the teaching of undergraduates.

Examples of projects in which we were extensively involved this past year are as follows:

1) Support to the undergraduates of the Student Committee on Educational Policy as they prepared their revitalized "Course Evaluation Guide." The guide, issued this spring, contained an evaluation of 75 fall 1981 subjects.

2) Publication of "The Torch or the Firehose?", a booklet designed to help recitation instructors, particularly graduate teaching assistants (TAs), with their teaching. Copies of this booklet, a combined effort of a number of faculty, staff, and graduate students, were distributed to all departments. The booklet was extremely well received and is being used by many departments for new faculty members as well.

3) Commencement of a TA support project in January 1982 in response to suggestions made at Dean Alberty's core curriculum group. Members of the group felt that the ODSA might talk to individual departments and instructors to explore further methods of supporting the teaching performance of TAs in recitations and laboratories, particularly in undergraduate subjects.

Interviews were held with individuals in various departments who conducted, or were planning to conduct, activities related to teaching support, and discussions were held with the five School Deans. Future plans include interviews with the departmental instructors and administrators suggested by the School Deans. As a result of the interviews held thus far, Dean Heine has begun consultations with members of the Department of Chemistry regarding improvements of laboratories and recitations for next fall, and Dean Meldman will be working with members of the Department of Architecture who are planning to hold a TA workshop during the fall term.

4) The sponsoring of a series of study skills workshops which train interested undergraduate and graduate students to run seminars or to help individual students.

Career and Course Orientation

Several activites were carried out which were designed to help students make decisions regarding departmental majors and career directions. 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.

Other activities in this area involved providing students with information about departmental open houses, helping the departments with plans for open houses and other activities to attract students as majors in the departments, and establishing a reading room for use by undergraduates as a central source of information about opportunities in departments.

Supervision and Coordination of Residence/Orientation

The Residence/Orientation (R/O) 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 Section. R/O Week 1981, under the coordination of Rhonda Peck, Class of 1982, expanded the activities for incoming women students and provided increased opportunities for students to become familiar with the Boston area. Ken Dumas, Class of 1983, is coordinating these efforts for the fall of 1982.

During the academic year 1981-82, we initiated the concept of continuing orientation to extend orientation throughout the freshmen year. We were able to bring together under one theme a number of independent offerings by other offices designed to introduce freshmen to various aspects of MIT life. We plan to expand our efforts in this important area during the next academic year.

HOLLIDAY C. HEINE
E. JANE DICKSON
JEANNETTE GERZON
JEFFREY MELDMAN
PEGGY RICHARDSON

STUDENT ASSISTANCE SERVICES

The Student Assistance Services (SAS) Section of the ODSA ends the year with far fewer uncertainties than we had when the year began. The goals and objectives we set for the past year were largely realized, the personnel of the office stabilized, and our identity as a Section was completed.

Concern with the identity of this Section has been a theme throughout the year. The formal integration of the International Students' Office into SAS was completed some time ago, but the psychological integration has taken longer, and the year has been marked by a growing awareness of the varied tasks of the Section and of each part of the OSDA. Increasingly, we are regarding what we do within ODSA as the many tasks of one office rather than the several tasks of several offices. This real integration of functions gives hope for the future as we draw increasingly on shared talent.

The primary goal for this Section continues to be the provision of personal counseling and programming that supports the personal growth and development of individuals. The three full-time counseling deans (Mary Hope, Linda Vaughan, and Robert Randolph) and the two half-time deans (Robert Halfman and Jeanette Gerzon) over the course of the past year had nearly 3,000 separate student appointments. When it is noted that, in addition, each of the more than 1,800 international students passes through this section at least once a year, it becomes clear that a significant portion of the MIT student body used our services this past year. Visits by graduate students increased fourfold over previous years, indicating that the idea of the Section as primarily for undergraduates is changing.

Perceptions have changed because there have been specific efforts made to increase student awareness of the services provided by the ODSA. This Section sponsored an open house for the community that brought in a number of people who had previously not been aware of our various functions. Dean Eugene Chamberlain continued his many activities with international

students as well as his involvement with the Graduate Student Council. Dean Halfman and Katharine Cutting offered increased support to undergraduate and graduate students seeking to study abroad. Throughout the year staff from the ODSA visited living groups, both on and off campus, and SAS has benefited from those visits. It is not at all uncommon for students to come in saying they did so because a member of the staff was at their house or dormitory for dinner and suggested they come by.

Increased visibility also has been helpful in getting more faculty involvement with this Section. In May alone, there were referrals from more than 40 faculty and staff. These referrals included some preparation for end-of-year meetings of the CAP, but they also indicate a growing interaction with the faculty. Also significant is that the number of minority students using our services has remained high, despite the absence of Dean Hope for nearly three months due to illness. This sustained use was due, in large measure, to an office-wide effort to create an atmosphere where all students feel they are welcome.

In the area of program development, we did not accomplish as much as had been planned. Individual members of the staff were involved in programs during IAP. Deans Vaughan and Hope worked closely with graduate and undergraduate students to plan and execute an excellent Black Science Conference. The groundwork was so well laid that the program actually generated enough money to reduce previous deficits. Other programs included sessions bringing together students and interested staff to discuss time away from MIT. There were a number of one-time efforts addressed to particular needs; however, the program part of our year took a back seat to the work with individual students.

SAS has continued to be responsible for providing services for minority, handicapped, and women students. Dean Hope drew widely from the human resources of the Institute in support of minority students. The programs generally went well with the science conference and the luncheon for parents of graduating minority students being two highlights of the year. A substantial amount of Dean Vaughan's time was spent providing special support services to these groups and especially to women and handicapped students. She had sustained and significant contact with graduate women in several departments, and her work with handicapped students continues to make it easier for them to cope with the many challenges of MIT.

Nightline, a peer counseling service, had an especially good year. The number of students working with this program has increased as has the number of calls. There have been several instances in which Nightline handled very sensitive issues with speed and collective wisdom. Dean Vaughan has helped in support of the program.

The *Sex* booklet of former years has been rewritten and christened *Human Relationships: A Sexual Perspective*. This book will be ready in the fall for distribution to freshman and other undergraduates and is expected to lay the groundwork for programs within the living groups.

We were able to do some research in an area of particular interest. Santiago Villenueva, who worked with us during the year while completing his degree at the Harvard School of Education, did some excellent background work on the question of what happens (and why) to students who simply did not return to MIT in the spring after a successful fall term this past academic year. These students have been identified and contacted, and we are in the process of examining the reasons for their not returning.

SAS remains an area where the more we do well, the more there is to do. Our challenge is to continually reflect on our charge while being sensitive to the changing needs of the students we serve.

ROBERT M. RANDOLPH
EUGENE R. CHAMBERLAIN
JEANNETTE L. GERZON
ROBERT L. HALFMAN
MARY O. HOPE
LINDA J. VAUGHAN

STUDENT ACTIVITIES

Students Activities and Governance

The twin themes of the "quality of student life" and "the quantity and type of social and cultural events" continued to dominate student concerns this past year in the areas of student activities and governance. These themes were discussed in a preliminary manner at the second conference sponsored by the Undergraduate Association at Endicott House last October. Beyond general aspirations for improvement, there continued to be only partial consensus on the details of "what," "how," and "for whom." Meanwhile, student volunteers involved in activities and governance seemed to have less total time to commit to these undertakings, and they looked for new patterns of management and operation for achieving objectives in these areas.

For both student activities and governance, it was a year of reappraisal and transitional progress. Dean McBay took the leadership in organizing meetings of student leaders and staff throughout the year in which questions were addressed of accountability, responsibility, and community with respect to financial operations and programs. Specific outcomes of these meetings included reports on the findings and recommendations of 1) a task force of students and ODSA staff on academics and student activities, chaired by Dean Meldman and 2) a similarly composed task force on the funding and use of funds by student organizations, chaired by Stephen D. Immerman of the ODSA staff. The former group focused on the relationship between academic performance and participation in student activities while the latter discussed funding needs and annual financial reporting procedures for student organizations. Some of these also were discussed by the Activities Development Board and the Committee on Student Affairs.

Within the Undergraduate Association, the General Assembly has sought to clarify the roles and relationships of the Assembly's standing committees to the General Assembly with a view toward reducing the existing confusion and toward increased cooperation. James T. Taylor, Class of 1984 and floor leader of the General Assembly, has given strong leadership to this process.

The Graduate Student Council again organized an outstanding program of orientation for new graduate students in September and February. During the year, the Council continued to assess the needs for graduate student housing, surveyed the potential decreases in financial support for graduate study, and reorganized the operations of the Muddy Charles Pub. Dean McBay convened several sessions of the executive committee of the Council with ODSA staff and Dean of the Graduate School, Kenneth R. Wadleigh, to discuss the status of recommendations regarding graduate student life contained in "The Dober Report" of 1978.

The 120 student activities categorized as general activities (interest groups), media, international, music and theatre, religious, service, and honorary generally enjoyed a productive year. Highlighting the year was the celebration in the fall of the 100th anniversary of *The Tech*. A second major event of the year was a spring weekend concert in the Athletics Center, sponsored by the Student Center Committee, Phi Sigma Kappa, and Theta Xi, which attracted 3,300 students and friends.

Reflecting the new interest in activity operations and management, approximately 25 students enrolled in the fall term seminar on leadership and time management conducted by Mr. Immerman and Dean Meldman.

Coordination of Women Students' Interests

The weekly Thursday series of afternoon programs in the Cheney Room, initiated in the prior year by Emily Weidman, the coordinator for women students' interests, continued with increasing response from the community. Established to provide speakers and to create a forum for discussion of women's issues, the series this year included such topics as "Women in Science: The Life and Career of Alice Hamilton, M.D.," "Women in Politics: A Look at State Government," and "Changes in Washington: The Effects on Women." A successful program series was held during IAP under the umbrella title, "Has Anything Really Changed for Women?" A Cheney program committee was established to plan these events.

Initiatives taken by the coordinator to meet the needs of women students included lunchtime meetings for women students in the Departments of Political Science and of Electrical Engineering

and Computer Science. During this second year of the program, the coordinator was asked to perform a liaison/communication role between groups such as the Association of MIT Alumnae, Society for Women Engineers, and the Association of Women Students. She also continued to provide staff support to the Advisory Committee on Women Students' Interests and assisted with the annual telethon to admitted women students.

Transfer Student Orientation

Orientation programs for undergraduate transfer students were held in September and January. There were 71 transfer students admitted for the fall term and 11 for the spring term. For the first time, all were offered housing accommodations as a result of the opening of the new dormitory at 500 Memorial Drive.

Use of Facilities

Good planning, mutual understanding, and a sense of fairness and sharing resulted in the accomodation of approximately 5,000 student and community programs in Kresge Auditorium, the Stratton Student Center, the Walker Memorial Building, and the MIT Chapel this past year. Deep appreciation is extended to everyone who helped make this productive use of community resources possible.

Talbot House

Talbot House continued to enjoy popularity with a variety of groups from within the MIT community. During the 1981-82 academic year, 55 different groups comprising 1,251 individuals stayed at Talbot House. These groups can be categorized as academic groups (18), living groups (15), clubs (15), and recreation groups (7).

This past year, Talbot House was occupied 43 weekends with 15 groups making visits during the week. January and February continued to be the most active months with eight different groups taking advantage of the accomodations during IAP.

As a result of escalating costs, the price structure was adjusted in September to reflect an increase in both meal prices and the per-night fees. We do not anticipate having to raise prices next fall because energy costs were not as high as expected. This was largely due to the energy conservation renovations made to the house this past year which reduced fuel consumption by about 30 percent.

ROBERT J. HOLDEN

RESIDENCE PROGRAMS

Institute Houses

The opening of the new 352-bed undergraduate residence at 500 Memorial Drive this past September contributed significantly to one of the smoothest R/O weeks in years. This new House, which solved the excessive crowding problems of recent years, was the most popular choice of freshmen and transfer students during the dormitory selection process.

This facility was formally dedicated on December 4, 1981, at a luncheon held in the 500 Memorial Drive dining room for Corporation members and guests. On that occasion, Houses one and six of the New West Campus Houses were also dedicated in honor, respectively, of James B. Fisk, Class of 1931, and George W. Thorn.

In fact, the addition of 352 new beds to the system allowed us, for the first time, not only to accomodate all transfer students and readmitted students who applied for housing, but also to offer the remaining spaces available in the system to a number of graduate students for the year.

The expansion of Spanish House to a second floor in New West Campus Houses was accomplished following two years of discussions with the residents. Our office also worked closely with a newly created Foreign Language Department Committee on Language Houses to discuss the graduate resident/tutor selection and evaluation process, and how we can work together with student residents to improve programs within the language houses.

The MIT-Wellesley College Residential Exchange program was resurrected for the first time in several years. We were able to accomodate exchange students during both IAP and the spring term and now hope to continue this residential exchange on a regular basis.

Faculty and Graduate Residents

Dr. and Mrs. Adrian Houtsma resigned as facutly residents in East Campus after 11 years in those roles in order for Dr. Houtsma to accept a teaching position at the Technical University in Eindhoven, the Netherlands. Succeeding the Houtsmas as faculty residents will be Professor Judith Kildow and her husband, Alfred. Professor Kildow is associate professor of ocean policy in the Department of Ocean Engineering.

The faculty and graduate residents program continued to make a major contribution to the ODSA's overall goal of supporting and complementing the academic program of the Institute. The faculty and graduate residents were actively involved in counseling and advising of the residents; hosting events for students, faculty, administrators, and alumni; maintaining community standards; advising house governments; supporting self-governance; and sponsoring and/or supporting educational, social, and cultural programming in their respective houses. Their commitment to a residence program of high quality and their personal contributions remain invaluable to the program.

Dining and Residence Programs

This past year marked the second full year of the implementation of the dining program at MIT with two full classes participating in the required dining program. Sophomores and freshmen in Baker House, McCormick Hall, MacGregor House, 500 Memorial Drive, East Campus, and Senior House were required to purchase the minimum level assigned to their house and class.

Other major accomplishments include the resolution of the dining issue on the east side of campus, the completion of an architectural study of Walker Memorial, a decision to allocate new space to the Kosher Kitchen, and the further development of programs throughout the dining system.

The final resolution of the East Campus/Senior House dining issue was without a doubt the highlight of the past year in the dining area. Since September 1980, students in these two houses have been required to purchase meal plans and use the facilities in Walker Memorial pending further study of the dining needs of students, faculty, and staff who live or work on the east side of campus. A thorough study of Walker Memorial, including various dining options and renovation needs, was completed, as was a proposal by students in East Campus and Senior House for the installation of kitchens in their respective dormitories.

The Walker study would cost several million dollars to implement and has been put on hold while the installation of kitchens in East Campus and Senior House was approved by the Executive Committee of the Corporation at its May meeting. In conjunction with this development, it has been decided that among the residents of East Campus and Senior House only incoming freshmen will be required to purchase meal plans in subsequent years.

Major progress was made toward a final resolution of issues related to the Kosher Kitchen. During the past year, new equipment was purchased and a Validine machine was installed to facilitate the transfer of meal plans to the Kitchen. Approval also was given to relocate the Kosher Kitchen from its present cramped quarters to the Campus Room of Ashdown House, a more central and spacious site. This move is dependent upon the Hillel Society's ability to secure the necessary funding.

Programming in the dining rooms and throughout the system was widespread and diverse, including freshman dinner night during R/O Week, "community dining" at Walker Memorial, five special dinner nights during the year, a series of nutrition workshops during IAP '82, two issues of

MIT Food Service News, participation in the OXFAM Fast For a World Harvest, numerous visits by faculty, seminar administrators, and ODSA staff to the living groups, a series of brunches on women's issues in Baker House, and a number of faculty/student dinners and study breaks throughout the houses. Feedback on these activities was very positive.

Fraternities and Independent Living Groups

This past year the independent residence system celebrated its 100th year of continuous operation at MIT, experience a number of major achievements, and reached crossroads which suggest new beginnings in several areas of operation.

MIT's oldest fraternity in continuous operation, Alpha Theta chapter of Sigma Chi, celebrated its centennial anniversary on Patriot's Day weekend while the system's youngest fraternity, Zeta Psi, successfully relocated to its newly renovated home at 233 Massachusetts Avenue.

Two years of work and research on group insurance were rewarded when a group insurance package for the system was finally put into place. The group plan, in which half of the system is currently participating, provides for replacement costs on the individual residences, as well as up to $10 million of liability coverage per house.

With regard to reducing governmental fees, a very important decision was handed down from the Massachusetts Department of Revenue. Kappa Sigma fraternity was granted a favorable response to its application for abatement from the Massachusetts Meals Tax. The Interfraternity Conference (IFC) will direct its efforts toward encouraging and supporting other houses seeking the same exemption.

Alumni contributions to the Independent Residence Development Fund have once again proven to be a valuable resource in funding renovation projects. With the balance in the fund dipping precariously low, the Alumni Interfraternity Conference (AIFC) and IFC together with the Alumni Fund coordinated an extra effort in securing additional alumni gifts. This effort produced the most successful student telethon to date.

Quality student leadership in independent residences is one critical component in ensuring the ongoing viability of the system. Toward the end of encouraging and supporting student leadership, our office, with sponsorship from the Sloan School, initiated an undergraduate seminar on the management of student organizations mentioned in the Student Activities Section of this report. The student response and evaluation of the seminar was gratifying, and plans are being formulated to expand the concept to include more students.

Another new initiative this past year brought together tutors from independent residences to discuss their roles and explore ways in which our office could be supportive. Programs were identified and implemented in living groups on an experimental basis, including discussion topics of time managment, financial aid, and substance abuse.

Graduate Student Housing Programs

During this past year, our office was particularly active in advising the house governments and community associations of the four graduate living units on campus (Ashdown, Eastgate, Tang, and Westgate). Working with the officers of the living groups, considerable time was spent in leadership development, encouraging regular meetings with residents, communicating with residents and appropriate MIT offices, problem solving, and providing a more active liaison with the Housing Office for needed repairs and assistance.

Another encouraging development was the introduction of monthly newsletters in Eastgate and Westgate married student apartments. These newsletters, written by residents and sponsored by the ODSA, have served to open the lines of communication among residents and to help create a sense of belonging to the MIT community.

All in all, this effort could be best characterized as a year of building personal relationships, communication, confidence, and momentum in an effort to increase student services to graduate students.

Long-range Housing for Graduate Students

The 1981-82 academic year saw the further analysis of data from the 1980 MIT Graduate Student Housing and Transportation Study and the first recommendations for changes in campus housing policy and long-range planning for graduate student housing. The Administrative Housing Group (AHG) completed its task this spring with the development of three policy papers on pricing, capacity, and on tenure and access. The recommendations encompassed within these papers reflect the general need of graduate students for affordable housing withing the campus boundaries and the communities surrounding MIT. It is acknowledged that failure to address this severe housing problem could result in MIT losing its competitive edge with schools that can now house their graduate students.

Briefly stated, the plan put forth in the three papers by the AHG would 1) increase the availability of financial resources through the development of a graduate housing reserve fund derived from an increase in the rents of on-campus residents; 2) use the funds so generated to renovate, lease, purchase, or build additional living units for single and married graduate students; and 3) target as the first project to be supported by these funds the renovation of the former Infirmary (350 Memorial Drive) into a residence for 45-50 single women graduate students. A list of other likely projects and sites was identified for future development, and some administrative policies affecting access were recommended to permit the new graduate student a greater opportunity to gain space in campus housing.

Approval for the renovation of 350 Memorial Drive was given by the Executive Committee of the Corporation at its May meeting, with the understanding that the initial use will be for single graduate women.

Discipline

Several discipline cases involving students and fraternities were heard by the residence program staff and the Committee on Discipline. Offenses included possession of illegal drugs, destruction of Institute property, assault and battery, harrassment, indecent exposure, threatening letters, forgery, and disruption of a professor's class. Resulting actions included suspensions from residences, Dean's Office disciplinary warnings and probations, and one suspension from the Institute for five years.

Many of these disciplinary cases repeatedly pointed out the need for better articulation and understanding of community standards and internal judicial procedures, both within the independent living groups and the Institute houses. Priority issues for ODSA in working with various student groups during the 1982-83 academic year include those of community standards and self-governance.

ROBERT A. SHERWOOD
PETER H. BROWN
STEPHEN D. IMMERMAN
ANITA T. WALTON

INSTITUTE UNDERGRADUATE HOUSE COUNT

Fall 1982

HOUSE	1 M	1 F	2 M	2 F	3 M	3 F	4 M	4 F	Other M	Other F	Total M	Total F	TOTAL	CAP	VACANCIES	CROWDS
Baker	45	29	63	36	78	21	40	25	1		227	111	338	337	6	7
Bexley	4	1	37	3	23	10	27	5	3		94	19	113	122	9	0
Burton	37	27	59	44	65	37	58	22	1	1	220	131	351	344	4	11
East Campus	44	16	119	27	68	16	69	20	2		302	79	381	367	0	14
MacGregor	58		78		83		63		27		309		309	324	15	0
McCormick		56		71		49		53		1		230	230	219	0	11
New House	46	7	47	7	53	4	40		1		187	18	205	220	15	0
French	4	2	4	5	8			3			16	10	26	26	0	0
German	3	1	4	3	5		2	3			14	7	21	21	0	0
Russian	5		2	2	4	2	3				14	4	18	18	0	0
Spanish	2	3		2	3		1				6	5	11	11	0	0
Random	20	10	17	9	10	2	20	1	1		68	22	90	93	3	0
Senior	20	10	42	12	42	6	31	13	1		136	41	177	183	6	0
500 Memorial Drive	157	59	33	3	30	9	35	7	1		256	78	334	352	18	0
TOTAL	445	221	505	224	472	156	389	152	38	2	1,849	755	2,604	2,637	76	43
	666		729		628		541		40		2,604					

RESIDENTIAL DISTRIBUTION OF MIT STUDENTS

Fall Term, 1981-82

Regular Graduate Students

MIT HOUSING	Men	Women	Total
Ashdown	331	57	388
Tang	345	59	404
Graduate Residents (Single)	24	17	41
Total Single Graduates -- On Campus	700 (19.2%)	133 (16.9%)	833 (18.8%)
Eastgate	168	29	197
Westgate	201	8	209
Graduate Residents (Married)	23	4*	27
Total Married Graduates -- On Campus	392 (10.7%)	41 (5.2%)	433 (9.7%)
Total Graduates -- On Campus	1,092 (29.9%)	174 (22.1%)	1,266 (28.5%)
OFF CAMPUS	2,557 (70.1%)	612 (77.9%)	3,169 (71.5%)
TOTAL REGULAR GRADUATES	3,649 (100.0%)	786 (100.0%)	4,435 (100.0%)

*In three couples, both members are students.

Department of Athletics

This report covers the second year of my tenure as director, and I wish to make special note of my continuing respect for the professional competence of our Department of Athletics staff and my admiration for their enthusiasm and dedication toward our fundamental purpose of enhancing MIT's academic and human environment by providing the highest quality recreation, physical education, and athletic programs.

The report will present a review of the wide-ranging intercollegiate, club varsity, intramural, physical education, recreational, and special events conducted for MIT students, faculty, staff, and the general community. We also will review the activities of selected program support areas and recap some of the more significant accomplishments and future priorities.

GENERAL OVERVIEW

Despite declining student enrollments, the academic year 1981-82 again showed strong broad-based participation in virtually all programs of the Department. In Physical Education, undergraduate registrations have increased for the third consecutive year, while the club sports with a net addition of four programs have reached an all-time high in number of programs and participants. Intramurals show some decline in number of teams and individual participations, which might partially be explained by the decrease in overall student population, although actual participation and number of activities continue to involve more than two-thirds of our undergraduates and a significant number of graduate students. Men's intercollegiate programs had an increase in participation for the third consecutive year; women's intercollegiate programs had a decrease in participation, although the total number of programs has been increased to 11 with the addition of cross country. Both men's and women's intercollegiate programs have greater than 18 percent participation from their respective undergraduate students.

PHYSICAL EDUCATION

There is a slight decline in total registrations (6,098 compared to 6,134 last year, but an increase over two years ago) and the third consecutive year of undergraduate registration increases (see Table I). There was also an increase in the number of classes offered (123 compared to 114 last year, including four cumulative quarters plus IAP). There were 633 graduate student participations and 275 staff.

The physical education curriculum included an impressive variety of 37 different offerings, with the addition of a new subject, Principles of Aerobic Conditioning. Two offerings were dropped (field hockey and basketball officiating) because of instructor Debbie Clum's leave of absence and lack of student interest. The most popular courses include dance (ballet, partner, and tap), self-designed fitness, weight room body development, skating, tennis, and sailing. The large enrollment in dance is partly attributable to an expansion of offerings by Instructor Riva Gibley to include courses in advanced ballet and movement for body conditioning with on-stage performances by both groups.

The following steps have been taken to undergird and improve the physical education program:

1) Expansion of yoga under the direction of William Kennedy will include an advanced class called For Discipline and Self Mastery in addition to the basic yoga class. We see this as a pilot program for possible expansion to all four instructional quarters to keep abreast of the growing interest in this timeless form of body stretching and conditioning.

2) The growing popularity of dance as a form of body conditioning will be recognized by the addition of a course in modern jazz dance in the fall of 1982.

3) Several new management control systems and procedures have been implemented, resulting in elimination of the "senior crisis graduation credit problem" and preparing the way for future steps to add computer and word processing capability to the Physical Education Office.

4) The popularity of self-designed fitness extends to the MIT faculty and staff. After a two-year trial period, we will institute a comprehensive satellite health fitness program in 1982-83, providing instruction three days per week in Building 8 and at the Alumni Pool, in addition to the regular noon and 5 pm classes daily in du Pont Athletic Center. Our program also includes a full summer session with trained instructors. Director Maggie Lettvin will continue to experiment through an 11 am beginners class to serve as an opportunity for faculty and staff with special needs and as a vehicle for new concepts and programs of health fitness. New programs will be implemented on a trial basis in a new evening program of body fitness mechanics.

5) The addition of Professors Francis O'Brien and Gordon Kelly to the administrative team of the physical education program has proven a strong source of support for Director Ed Crocker and the program. They served as acting co-directors during Professor Crocker's sabbatical leave and continue as permanent assistant directors. Clerical support for all three directors has been ably provided by Karen Dargan who is pursuing additional training in the use of computer equipment and administration procedures.

The upgrading of the physical education program continues to be a major priority, reflected in the recently created Physical Education Advisory Committee, in plans to create and test new curriculum to reflect changing societal patterns of health fitness and MIT student backgrounds, in increased emphasis on instructor in-service training, and in increasingly sophisticated record-keeping and managment control procedures.

One component of the new curriculum plan involves evaluation of students' physical characteristics and capabilities. This area would require collaboration between the physical education and sports medicine programs.

A major focus of the new curriculum plan involves evaluation of incoming MIT students on the basis of flexibility, lower and upper body strength, body fat percentage, coordination, and various physical skills. This data will allow compilation of valuable research information for future re-evaluation comparisons, responsible assessment of a student's immediate health fitness needs, selection of appropriate topics for general dialogue, and individualized recommendations for physical education courses to improve and maintain health fitness status.

CLUB ATHLETICS

Reaching an all-time high in number of programs and participants (see Table II) under the continuing effective leadership of Professor John Barry, the 1981-82 season was characterized by a strengthening of current clubs and the formal addition of six new clubs (net addition of four). Ice Dance, a splinter group of Figure Skating, became the 29th recognized club, and women's soccer is preparing to become the 30th next fall. A slightly larger club budget has contributed to the increase in interest and support of the club program. The new Athletics Center ice rink has resulted in a large increase in Figure Skating Club membership and the production of two well-attended major ice shows.

Bowling and Table Tennis competed in the American College Union Tournaments and both went to the Eastern Championship final round. Bowling finished second; Table Tennis finished second in doubles and third in singles.

The club athletic program continues to be a major area of graduate student opportunity and participation. We believe a strong club program at MIT is essential to ensure diversified competitive and recreational activities for our large graduate population.

INTERCOLLEGIATE ATHLETICS

High-level intercollegiate competition and skill development for MIT undergraduate men and women is offered in 32 athletic programs (see Table III) with participation this past year totaling 834 undergraduate men and women (compared to 856 last year) and represents over 18 percent of the total undergraduate enrollment.

The men's intercollegiate teams enjoyed a solid winning percentage of .481 compared to .519 last year with nine of the won-lost record teams having a winning edge. Women's intercollegiate teams also had a solid winning percentage of .441 (up from .405 last year) with two of the 11 teams, volleyball and softball, enjoying winning seasons and Massachusetts state championships.

Championship Competition

MIT was the host of several major championships during the past year, and we will continue to conduct such events in our role as leaders of amateur athletics in the Boston area and throughout New England.

Men's Intercollegiate Achievements

- Competing in the Greater Boston League, the baseball team beat Division I rivals Harvard and Northeastern leading to a 10-11 record (most wins in a season since 1976).
- The lightweight crew team won three of four regattas and finished fourth in the grand final at the Eastern Sprints on Lake Quinsigamond in Worcester. In Jope Cup standings (points in Eastern competition), MIT was fourth behind Harvard, Princeton, and Yale and ahead of Penn, Dartmouth, Navy, Rutgers, Cornell, and Columbia.
- The cross country team competed in the NCAA Division III championships for the third straight year and posted a 4-2 record for its fourth consecutive winning season.
- The fencing team was 9-5 (its 13th consecutive winning season), won the Iron Man Trophy (team foil champion) at the Intercollegiate Fencing Association meet for the fourth time in eight years, captured the New England Championships for the 13th straight time, and competed in the NCAA Championships for the third consecutive season.
- The highly regarded golf team were 10-4-1 this past spring for their sixth straight winning season (57-24-1 over that span). The team also finished eighth at the New England Championships.
- The gymnastics team posted a fine 8-2 record for its best mark in 10 years. The team also finished second at the New England Conference meet.
- The pistol team posted a 6-2 record, and finished second in air and free pistol and fourth in standard pistol at the National Championships. It also finished first in all three weapons at the Intercollegiate Sectional held at MIT.
- The swimming team had a 4-4 record in dual meet competition; however, the team finished seventh in a field of more than 40 schools at the NCAA Division III Championships.
- The indoor track team posted a perfect 10-0 record for its best mark in 85 years. The team also captured the New England Division III Championships for the second straight year and finished 11th in the Open New England Championships.
- The outdoor track team won its second straight New England Division III title (its fourth consecutive New England Division III Indoor crown). The Engineers posted a 3-1 record in a dual meet competition losing only to Division I New Hampshire.
- The water polo team posted a 7-15 record against its toughest competition ever. The Engineers played Caltech in the first intercollegiate athletic contest between the two schools, losing 15-9.
- The wrestling team compiled a fine 14-5 record (the most wins in a season since 1969). The Engineers also won the Northern New England Championships for the first time and finished seventh at the New England College Conference meet held at MIT.

Women's Intercollegiate Achievements

- This was the first season of varsity competition for the cross country team, which competed in six meets posting an overall record of 3-8.
- The softball team posted its best season ever in six years of varsity competition with an 11-4 record. The team also won the Massachusetts Association of Intercollegiate Athletics for Women (AIAW) Tournament (Class "C" division) with a pair of wins over Curry and Western New England colleges.
- The volleyball team competed in the Eastern AIAW Division III Championships at West Point winning two of four matches. It also won Massachusetts AIAW Tournament leading to a 31-8 record, the squad's best mark in seven years of varsity competition.
- Karen Klincewicz, Class of 1982, received the Betsy Schumacker Award for excellence in athletic competition by an undergraduate woman. She also received All-American honors in five events this season at the AIAW Division III swimming championships. She was selected for a $2,000 NCAA postgraduate scholarship and was the first MIT woman athlete so honored. Ms. Klincewicz also was awarded one of the Malcolm G. Kispert Awards presented annually to the male and female senior scholar-athletes of the year.
- Linda Plano, Class of 1982, received the Pewter Bowl Award given annually to a female senior who has shown the highest qualities of inspiration and leadership in contributing to women's athletics. Ms. Plano was captain of the women's volleyball team, which posted its best record (31-8) and won the Massacusetts AIAW Division III Regional at West Point winning two of four matches.
- Melissa Hines, Class of 1984, women's crew manager, received one of the Burton R. Anderson, Jr., Awards presented to the outstanding managers of the year for a men's and women's intercollegiate team.
- Ya-Pei Chang, Class of 1983, was New England collegiate runner-up in fencing. She competed in the national AIAW fencing championships in Madison, WI.

INTRAMURAL ATHLETICS

While intramural athletics (IM) continue to enjoy the largest student participation of any Department program, the annual statistics show a decrease in number of teams and particpating students. Seventeen of the 27 programs offered had fewer student entries than last year, and we did not conduct a table tennis season which last season accounted for over 500 student participants. One activity, seven-a-side rugby, was reintroduced with a successful one-day tournament.

We estimate that more than 60 percent of the total undergraduate enrollment is involved in at least one of our 27 programs. There were 10,857 cumulative student participations (compared to 12,067 last year and 11,200 two years ago).

Several steps were taken by the student IM leaders to improve the quality and efficiency of the IM program: a du Pont Athletic Center mailbox pickup system was instituted to improve communications; responsibility for coordination of equipment issue, goal and flag setup, and referee reassignment was successfully delegated to the fall season IM field supervisors; and a student referee club was established.

In the coming year, highest priority will be given to new methods for dealing with the problem of escalating referee costs, increasing absenteeism, and declining quality of officiating; and to implementation of the women's study by Assistant Professors Jean Heiney and Candace Royer which recommended that all-women's leagues should be offered in soccer, volleyball, basketball, and softball (currently all these activities are coed). This would include appropriate delineation by skill level and strong supporting publicity, including revision of the Intramural Handbook.

COMMUNITY RELATIONS AND GENERAL RECREATION

Recreation and Instruction for the MIT Community

An increasing diversification of programs was offered throughout the year to children of the MIT community, including ice skating and swimming instruction and eight weeks of MIT Summer Day Camp for about 210 children per week. Adult instructional programs were again offered in cardio-pulmonary resuscitation, self-designed fitness, golf, sailing, swimming, sculling, tennis, and dance.

We successfully expanded the Open Swim hours to include an 8-9 am period twice a week. The 8 am daily opening of the Har-Tru tennis courts has been continued for the second consecutive spring season.

The Community Softball League Program continues to operate successfully in the summer months with more than 75 teams.

Athletic Card Program

Both athletic and sailing card sales increased for the third consecutive year. Student sales are equivalent to last year's, but faculty and staff sales are up significantly.

Athletic Card Sales

	1981-82	1980-81
Students	6,913	7,024
Faculty	424	331
Staff	1,822	1,721
Family	499	438
Alumni	416	354
TOTAL	10,074	9,868

Sailing Card Sales

Student	1,436	1,442
Faculty/Staff	220	217
Alumni	91	91
Special Family	197	166
TOTAL	1,944	1,916

For the academic year 1981-82, a new concept was initiated by Equipment Manager, John Murphy, for the sale of student athletic cards. Instead of selling different colored cards every year we are using the student ID card; the reverse side has a place for a sticker indicating the term and local address. By placing a validating sticker (with a different color every year) after payment of regular fees, a freshman can use the same ID card for his or her tenure at MIT. This innovation has proven to be extremely successful and has resulted in positive identification of students, substantial saving in the cost of printing, the elimination of transferring cards, and increasing sales.

Due to the success of the new student ID system, plans are now being formulated to revise the present ID card for employees, staff, and faculty.

Boston/Cambridge Community Relations

The Institute has maintained a policy of making our athletic facilities available for use by Cambridge and Boston community groups. We continue to make every effort to schedule outside groups to avoid conflict with use of facilities by the MIT community. Our emphasis is to accomodate youth and underprivileged groups which the local community might find more difficult to satisfy for various reasons.

MIT ATHLETIC FACILITIES

The MIT Athletics Center was officially dedicated in December 1981. In its second year of operation, the Center continues to expand student opportunities and enrich student lives at all levels of our program.

The du Pont Gymnasium floor was replaced with a new maple floor in the summer of 1981 which proved to be a significant improvement, providing for a permanent equipment site for men's and women's gymnastics.

The area A field lighting program, completed and in operation for outdoor spring activities, had a significant impact on student usage. Intramurals enjoyed the greatest benefit with many more hours available for frisbee and softball. With the fall 1982 season, we expect a similar impact on the intercollegiate programs because of limited practice field space during daylight hours.

Other areas of important facility improvement completed during 1981-82 include resurfacing of all hard tennis courts at du Pont and Walker, and improving existing surface on Tang Courts; renovation of the men's training room into a coed sports medicine facility with modern equipment for medical care and rehabilitation; acquisition of four sections of portable bleachers, creating spectator seating for 240 people; application of a seal coat to the California Product floor in Rockwell Cage; and relocation and purchase of a new men's sauna.

The Physical Plant/Department of Athletics transition plan is scheduled to take effect September 1, 1982. Several meetings between the two departments have been held, and the basic thrust of the plan is to transfer personnel management to the Department of Athletics for those Physical Plant employees currently working at Pierce Boathouse, Alumni Pool, and the Sailing Pavilion, and transfer to Athletics the appropriate Physical Plant budgeted funds for support of the facility management transfer.

Future facility plans include updating and modernizing our weight training facilities and programs, providing more sophisticated equipment with supervision and instruction for users; fabricating a secure shop area in the Athletics Center garage to facilitate work of utility personnel; improving playing surfaces on Briggs Field, possibly with grass and artificial turf; installing suspended basketball backboards on the IM courts in Rockwell Cage; and constructing a small locker-shower facility at the Carr Tennis Bubble.

SPORTS MEDICINE AND TECHNOLOGY/HEALTH FITNESS

Under the effective first-year leadership of the sports medicine program coordinator Paul Grace, the highlight of the past year was the completion and implementation of the coeducational athletic training facility in du Pont. The facility has already brought a renewed spirit of cooperation and will result in a significant improvement in the consistent delivery of student services and an upgrading of the professional atmosphere for the sports medicine staff and Medical Department orthopedic physicians.

We also have been able to expand the numbers of those receiving athletic training services with the addition of several pieces of rehabilitative equipment and therapeutic modalities. The equipment also allows the sports medicine staff to treat effectively a wider variety of injuries and orthopedic conditions.

In conjunction with the treatment and rehabilitation of athletic injuries, Paul Grace and the sports medicine group will work closely with the assistant director of athletics, Jane Betts, in assuming more responsibility for the layout, organization, and supervision of the du Pont weight training/health fitness center. This will provide greater consistency in the creation of remedial exercise programs for the physical education program; in collaboration with coaches on intercollegiate team exercise programs; in training of supervisors to oversee general community usage; in coordination of orthopedic physician referrals; and in the overall scheduling of various usage groups.

It is envisioned that the emerging MIT health fitness center will develop a research laboratory capability enabling the sports medicine program to investigate such areas as cardiac testing and

conditioning, body fat/weight density testing, muscle strength and training, flexibility, and general body condition and care.

The concept of technology health fitness has continued to develop; in practice, the Department of Athletics is to serve as a catalyst and coordinator for controlled technology-based research activities related to the health fitness needs of our society. These research activities would draw upon the expertise and experience of the MIT faculty and use MIT facilities where possible.

A current technology/health fitness project is to design an instrument with Dr. Robert Mann, Department of Biomedical Engineering, that will quantitatively and objectively assess ankle joint/subtalar range of motion.

Currently, no device provides such objective measurements. During the next academic year, we will be testing and re-evaluating a prototype in the sports medicine service program. After all tests are completed and data collection begun, a sports medicine specialist will be able to assess an athlete's subtalar motion in order to prevent or rehabilitate injury.

A two-part presentation on the lower back and individual nutritional assessment was given in February at Endicott House for participants in the Sloan School's Program for Senior Executives. The presentation was in collaboration with Alan F. White and H. Scott Duncan, director and associate director of Sloan's executive education programs. It will be repeated in the fall of 1982 and spring of 1983. This summer an expanded program will be initiated with the Sloan Fellows Program.

Drs. Ernest Cravalho and Stephen Burns, Harvard-MIT Division of Health Sciences and Technology (HST), continued our past collaborative efforts toward the joint purchase of a microprocessor This will enable both departments to continue their collaboration on quantitative instrumentation of isokinetic data collection. Additionally, preliminary work is being discussed to begin the implementation of a data management system for sports medicine.

For the past two years, as a result of our project with Dr. Burns, the Department began to utilize the Cybex system on a regular basis as part of its research and service program.

The machine was initially loaned to MIT for research in the area of quantitative instrumentation development. Because the system has become an integral part of the work of the Department and HST, it was decided to purchase the system. A proposal to Provost Francis Low was approved to provide funds for a non-recurring equipment purchase. The purchase of this system will now assure the Department's growth in the area of research and development in sports medicine.

Beginning in the fall of 1982, the sports medicine and physical education programs will plan, organize, and direct a pilot research project for students enrolled in selected physical education classes.

The major focus of this project will involve assessment of components of students' fitness (pre-test), assignment of selected activities for fitness improvement, presentation and discussion of selected health topics, introduction to various sports skills for individual sports, and re-evaluation (post-test). By initiating this limited study, it is believed that in the future all freshmen will be evaluated on their health/fitness status and directed to the appropriate physical education course. At the conclusion of their freshman year, they would be given appropriate recommendations for the maintenance or improvement of their fitness status.

Sports Publicity and Information

The Sports Information Office, ably led by Kenneth Cerino, enjoyed a busy but highly successful year. In addition to the tremendous volume of regular program support, Mr. Cerino and his staff were involved with five major New England tournaments or championships. The Office also provided major publicity support for Homecoming 1981 and the May 1982 Community Service Fund Road Race.

Other accomplishments included a feature article on MIT basketball captain Mark Branch and the NCAA Volunteers for Youth Program in *The New York Times*. Profiles on coaches Walter Alessi (lacrosse) and Christopher Lane (women's cross country) appeared in area newspapers. In addition, noted sports artist LeRoy Neiman sketched the cover for the New England Division III Indoor Track and Field program.

Articles on MIT student athletes continue to appear in hometown newspapers; men's football and basketball results appear in newspapers across the country via the national wire services.

From time to time, the Sports Information Office also provides items of interest and pictures to *Technology Review*.

Among the objectives for 1982-83 are additional feature articles on MIT student athletes, coaches, and various Department programs. In addition, the Office is compiling a list of the all-time records for the Institute's 32 intercollegiate varsity sports teams along with a list of every letter winner in MIT history.

The Department of Athletics is planning to update and resize its general brochure (the last one was printed in 1977) which includes information on physical education, intercollegiate athletics, club and intramural sports, facilities, and general recreation. The new brochure also will be used by the Admissions Office for prospective student athletes.

Another possible publication for 1982-83 is a trip guide showing the best way to get to MIT, including a campus map, list of motels, and restaurants. Primary benefactors of this publication are the various opposing sports teams who visit MIT during the year along with prospective student athletes.

Staff Accomplishments

Professor Barry, assistant director of athletics, was named director of the Greater Boston Intercollegiate Golf Tournament; vice president of the New England Intercollegiate Golf Association; and member of the selection committee for the NCAA Division III golf championships.

John Benedick was elected to the NCAA Water Polo Committee for a three-year term 1982-85. Mr. Benedick is also head swimming coach.

Jane Betts, assistant director of athletics, served as Division III vice president of the AIAW; was co-director of the 1982 AIAW national rowing championships; and was elected president-elect of the Eastern AIAW for 1982-83.

Mr. Cerino, sports information director, was named president of the Eastern College Athletic Conference Sports Information Directors Association (ECAC-SIDA) for 1982-83; he also served as 1982 Greater Boston League Baseball Publicity Director.

Professor Kelly, head coach of track, was named 1981 New England Division III Indoor and Outdoor Track Coach of the Year and named president of the New England Division II Track and Field Coaches Association for 1982-83.

Mr. Murphy, equipment supervisor, completed his 34th year as a member of the Department of Athletics staff.

Eric Sollee, fencing coach, has earned the Master of Arms certification by the Academy of Arms Division of the National Fencing Coaches Athletic Association.

F. Timothy Walsh, wrestling coach, was named Massachusetts cochairman of the United States Wrestling Federation.

Staff Changes 1981-82

New Appointments

Thomas F. Perry, head coach of rifle, part-time.

Halston W. Taylor, instructor of Physical Education, head coach of men's cross country, assistant coach of track (effective 1982-83).

Resignations

Deborah S. Clum, instructor of Physical Education, head coach of field hockey and softball.

Robert B. Horwitz, head coach of men's gymnastics, part-time.

Thomas Howes, freshman coach of heavyweight crew, part-time.

Michael William Rubin, varsity coach of lightweight crew, part-time.

Clifton L. West, assistant professor, head coach of men's cross country, assistant coach of men's track.

ROYCE N. FLIPPIN, JR.

TABLE I

MIT ATHLETIC PROGRAM PARTICIPATION

STUDENT ENROLLMENT (October Figures -- includes Specials)	1981-82	1980-81
Undergraduate Women	977	891
Undergraduate Men	3,585	3,686
TOTAL	4,562	4,577
Graduate Women	786	846
Graduate Men	3,649	3,942
TOTAL	4,435	4,788
GRAND TOTAL STUDENTS	8,997	9,365

STUDENT PARTICIPATIONS (Includes Multiple-Activity Duplication)	1981-82	1980-81
PHYSICAL EDUCATION		
Programs	37	38
Total Registrations	6,098	6,134
(Undergraduate)	(5,190)	(5,156)
(Graduate)	(633)	(708)
(Staff)	(275)	(270)
INTRAMURALS		
Programs	27	28
Teams	1,151	1,289
Students	10,857	12,067
CLUBS		
Programs	29	25
Students	740	589
INTERCOLLEGIATES		
Women's Programs	11	10
- Student Participants	189	233
- Letter Awards:	143	145
(Varsity)	(95)	(94)
(Junior Varsity)	(29)	(31)
(Frosh)	(19)	(20)
Men's Programs	21	21
- Student Participants	645	623
- Letter Awards	457	475
(Varsity)	(271)	(259)
(Junior Varsity)	(137)	(142)
(Frosh)	(49)	(74)

TABLE II

CLUB PROGRAMS

	1981-82	1980-81
(1) Aikido	15	--
Archery	11	11
Badminton	20	16
(1) Bowling	11	--
Cheerleading	12	12
Cricket	24	23
Fencing	25	24
Figure Skating	55	23
Football	45	47
Folk Dance	40	35
(2) Frisbee	60	40
Hockey, Men	25	26
(2) Hockey, Women	26	24
(1) Ice Dance	30	--
Judo	--	10
Karate, Shotokan	30	24
(1) Lacrosse, Women	12	--
Rifle and Pistol	45	45
Rugby, Men	47	45
Rugby, Women	17	15
Scuba	25	26
(2) Society for Creative Anachronism	20	14
Soccer, Graduate Men	24	20
Square Dance	--	22
Table Tennis	14	16
Tae Kwon-Do	24	22
Volleyball, Men	20	15
Water Polo, Women	13	14
White Water	20	20
(1) Wu-Tang Boston	15	--
(1) Wu-Tang MIT	15	--
TOTAL PARTICIPANTS	740	589
TOTAL PROGRAMS	29	25

(1) New Clubs 1981-82

(2) New Clubs 1980-81

TABLE III

MIT VARSITY COMPETITIVE RECORDS IN
INTERCOLLEGIATE ATHLETIC COMPETITION 1981-82

MEN'S SPORTS (19 Sports Listed)[1]

	Won	Lost	Tied	
Fall				
Cross Country	4	2		
+Golf	4	2		
Soccer	1	11	1	
Water Polo	7	15		
Winter				
Basketball	7	17		
Fencing	9	5		
Gymnastics	8	2		
Pistol	6	2		
Rifle	14	19		
Squash	4	15		
Swimming	4	4		
Track, Indoor	10	0		
Wrestling	14	5		
Spring				
Baseball	10	11		
Crew, Heavyweight	1	8		
Crew, Lightweight	4	2	1	
+Golf	10	4	1	
Lacrosse	4	8		
Tennis	5	6		
Track, Outdoor	3	1		
TOTALS 1981-82	129	139	3	(.481)
1980-81	125	116		(.519)

WOMEN'S SPORTS (10 Sports Listed)[2]

	Won	Lost	Tied	
Fall				
Cross Country	3	8		
Field Hockey	3	11		
+Tennis	4	7		
Volleyball	31	8		
Winter				
Basketball	5	17		
Fencing	7	7		
Gymnastics	4	7		
Swimming	1	7		
Spring				
Crew	0	8		
Softball	11	4		
+Tennis	2	6		
TOTALS 1981-82	71	90		(.441)
1980-81	53	77	1	(.405)

(1) No won-lost record for Sailing and Skiing

(2) No won-lost record for Sailing

1981-82 CLUB VARSITY SPORTS

	WON	LOST
Football	2	6
Men's Ice Hockey	12	4

+ Play combined fall-spring schedule

MIT Press

Although the Press's financial performance was mixed, primarily because of depressed sales in foreign markets, this year was one of growth and accomplishment overall.

We published 121 books: 83 new hardcovers, 32 paperback reprints, and six original paperback titles. It was the most well-received new list to date, with sales exceeding last year's new list by 33 percent. The best selling professional books were *Robot Manipulators: Mathematics, Programming and Control* by Richard Paul and *Turtle Geometry: The Computer as a Medium for Exploring Mathematics* by Hal Abelson and Andrea diSessa. *MX: Prescription for Disaster* by Herbert Scoville was our overall best seller at 12,000 copies. Best selling new paperbacks were *Buffalo Architecture: A Guide* by Reyner Banham; *Brainstorms: Philosophical Essays on Mind and Psychology* by Daniel C. Dennett; *Hemotology*, third edition, by William S. Beck; and *Technology in America: A History of Individuals and Ideas* by Carroll Pursell. A total of 441,000 copies of our books was sold for a net income of $4,535,000.

Equipment for our new computer typesetting facility was installed, several books were produced on the system, and we successfully completed our fund-raising effort for the system, with outside funds covering approximately 65 percent of its total cost. We acquired two new journals: *International Organization* and *Space and Society*, and published the first issue of our new journal, the *International Journal of Robotics Research*. The bookstore continued to exceed all expectations, and the journals division showed its first significant profit since we began developing the program six years ago.

The American Institute of Architects (AIA) awarded the Press a gold medal, the first ever to a publishing company, for "continuously publishing significant and serious books in architecture over a span of many decades." The Press also received two awards from the Association of American Publishers (AAP): the R.R. Hawkins award for the Outstanding Technical, Scientific, or Medical book of 1981 for the *Le Corbusier Sketchbooks* (shared by the co-publisher, the Architectural History Foundation); and the award for the most creative and innovative new professional or scholarly project, *Humanscale 4/5/6* by Neils Diffrient, in the Journals, Looseleaf, and Other Media category. The 1981 Dexter Prize of the Society for the History of Technology was awarded to *Transatlantic Industrial Revolution: The Diffusion of Textile Technologies Between Britain and America, 1790-1830s*. The American Institute of Graphic Arts awarded MIT its second Design Leadership Award for "its recognition of the cultural and communicative value of excellent graphic design to its community and audience." The MIT Press, one of the three departments cited, was singled out "for sustaining a continuing commitment to the art of the book."

Faculty serving on the MIT Press editorial board in 1980-81 were Professors Suzanne Berger, Sylvain Bromberger, Peter Elias, Robert Jaffe, Carl Kaysen, Leo Marx, William L. Porter, and Robert Weinberg. Jay K. Lucker, Constantine B. Simonides, and Frank Urbanowski served as ex-officio members. Professor Hartley Rogers, Jr., stepped down as chairman of the editorial board this year, and Professor Ascher Shapiro, formerly a board member, became chairman in January.

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; John Deutch, professor of Chemistry, MIT; Norman Pomerance, senior vice president of Harper & Row; and Alvin J. Silk, professor of Management Science at the Sloan School. Professor Shapiro, chairman of the editorial board, and Mr. Urbanowski, director of the MIT Press, are ex-officio members. Mr. Simonides, vice president in the Office of the President, is the chairman of the management board.

BOOK DIVISION

The Press concluded this fiscal year with a net operating loss of $399,000, made up of a $545,000 loss by the Books Division on sales of $4,535,000, and a $146,000 surplus in the Journals Division.

This deficit will not be funded by the Institute but will be carried forward on the Press's balance sheet, to be reduced by future revenues. Book sales were originally forecast at $4,900,000. Sluggish domestic sales and decreased sales in the United Kingdom and Europe contributed to the sales shortfall and reduced gross margin. The Press Bookstore, originally budgeted for an expense of $10,000, broke even this year.

The total working capital advanced by the Institute was less than the original forecast, resulting in only nominal interest charges of $8,000 compared to the $30,000 expense budgeted.

COMPARATIVE OPERATING DATA

	Fiscal Year 1982		Fiscal Year 1981
	Actual	Forecast	Actual
Total Net Sales	4,535,000	4,900,000	4,210,000
Cost of Sales	2,154,000	2,330,000	1,714,500
Gross Margin	2,381,000	2,570,000	2,495,500
Other Income	35,000	42,000	37,000
Total Income	2,416,000	2,612,000	2,532,500
Operating Expenses	2,953,000	3,100,000	2,694,400
Interest Charges	8,000	30,000	-
Net Books Division	(545,000)	(518,000)	(161,900)
Bookstore		(10,000)	(16,000)
Journals Surplus	146,000	92,000)	2,000
NET	(399,000)	(436,000)	(175,900)

BOOK PROGRAM

List planning and focusing remained a fundamental component of the acquisitions program with continued developmental efforts and emphasis in architecture, economics, computer science, cognitive science, physical sciences, and engineering. Last year, we acquired the imprint and ongoing projects of Bradford Books, Inc., publishers in the cognitive sciences. The imprint has been successfully incorporated into the Press, resulting in a considerable increase in our cognitive sciences list.

The book program continued to produce many outstanding books in a wide variety of disciplines. The following table illustrates the total number of books published within each discipline:

NEW BOOKS PUBLISHED IN FISCAL YEAR 1982
BY CATEGORY

	New Hardcovers	Original Paperbacks	Paperback Reprints	Total	Percent
Humanities	17	1	13	31	26
Architecture and Urban Planning	15	1	6	22	18
Biology and Health Sciences	12	-	2	14	12
Economics, Management, and Labor	11	-	2	13	11
Cognitive Science and Linguistics	8	3	2	13	11
Physical Sciences and Mathematics	7	-	12	8	7
Social and Political Sciences	6	1	3	10	8
Technology Issues	3	-	-	3	2
Engineering and Materials Science	2	-	-	2	1
Electrical Engineering and Computer Science	2	-	3	5	4
TOTAL	83	6	43	121	100%

Outstanding scholarly and professional books published this year were: *Robot Manipulators* by Richard Paul; *Essays in Economics* by James Tobin; *Models of Bounded Rationality* by Herbert Simon; *Welfare, Planning and Employment* by Abrams Bergson; *The Enchanted Ring* by John Sheehan; *Philosophy of Mathematics and Deductive Structure in Euclid's Elements* by Ian Mueller; *Ferdinand Braun* by Friedrich Kurylo and Charles Susskind; the third volume of *The Collected Papers of Norbert Weiner; Langrangian Analysis and Quantum Mechanics* by Jean Leray; *From Images to Surfaces: A Computational Study of the Human Early Visual System* by William Grimson; and the *Industrial Energy Conservation Manuals,* edited by Elias Gyftopoulos, a set of 17 manuals on energy conservation, which is part of a larger collection of information on industrial energy conservation developed by project PROCEED (Program for Continuing Engineering Education). The PROCEED system was pioneered by MIT's Center for Advanced Engineering Studies and represents a unique advance in engineering education, information science, and technology transfer.

Series have continued to grow in importance as part of the Press's program. Two new series were added to the computer science and engineering program. The Press, in conjunction with the McGraw-Hill Book Company, will publish a series of texts written by faculty members of the Department of Electrical Engineering and Computer Science. The Press also will cosponsor the Association for Computing Machinery (ACM) Doctoral Dissertation Award (conceived of by Frank Satlow, acquisition editor in computer science and engineering) and publish the winning theses.

Among the outstanding trade books published this year were: *MX: Prescription for Disaster* by Herbert Scoville, Jr., this year's best selling title with combined hard and paperback sales of almost 12,000 copies; *I Sought My Brother* by Allen Counter and David Evans; *Technology in America: A History of Individuals and Ideas* by Carroll W. Pursell; *Getting Sued and Other Tales of Engineering Life* by Richard Meehan (a graduate of MIT); *Clipped Wings: The American SST Conflict* by Mel Horwitch; *The Spirit of Color* by Karl Gerstner; *Observing Visual Double Stars* by Paul Couteau ("one of the most important books ever published for the dedicated stargazer" -- *Astronomy Magazine*); *Revealing the Universe: Prediction and Proof* by James Cornell and Alan Lightman; *Life in the Universe* by John Billingham; *Bringing Aerodynamics to America* by Paul Hanle; *The Watercolours and Drawings of Thomas Bewick and His Workshop Apprentices* by Thomas Bewick; *Experiments in Gothic Structure* by Robert Mark; *The Art of Building in Yemen* by Fernando Varanda; and *The Myth of Masculinity* by Joseph Pleck.

In the reference book program, the Press published *The Manual of Cultivated Orchid Species* by Helmut Bechtel, a beautiful book that quickly established itself as the authoritative reference in the field; and *The Dictionary of Modern Economics* by David Pearce.

The first four books in the German Social Thought Series were published this year: *Prisms* by Theodor Adorno, *Hegel and the French Revolution* by Joachim Ritter; *History and Structure* by Alfred Schmidt; and *Reason in the Age of Science* by Hans George Gadamer. *The Logical Problem of Language Acquisition,* edited by C.L. Baker and John McCarthy, inaugurated the Cognitive Theory and Mental Representation series. The Oppositions Books Series, published in conjunction with the Institute for Architecture and Urban Studies, was launched with the publication of *Architecture of the City* and *A Scientific Autobiography,* both by Aldo Rossi, and *Essays in Architectural Criticism* by Alan Colquhoun. Other series books were: *The Economics and Politics of Oil Price Regulation* by Joseph P. Kalt and *Studies in Public Regulation* edited by Gary Fromm (Regulation of Economic Activity Series); *Controlling Hospital Costs* by Paul Joskow (Health and Public Policy Series); *Prohibitive Policy* by Stephen L. Jaffee (American Politics and Public Policy Series); *Discrimination in Mortgage Lending,* by Robert Schafer and Helen Ladd (Joint Center for Urban Studies Series); *Robot Manipulators* by Richard Paul (Artificial Intelligence Series); and *Le Corbusier Sketchbooks 1, 2, 3 and 4,* and *The Hanna House Documents* by Paul R. and Jean S. Hanna (Architecural History Foundation). A series in Neuroscience and Neurolinguistics is being developed.

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; Linguistics Inquiry Monographs); Jay W. Forrester (MIT Press/Wright Allen Series in System Dynamics); Alan S. Willsky (Signal Processing, Optimization, and Control); Marvin L. Manheim (Transportation Studies); 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); Thomas McCarthy (Studies in Contemporary German Social Thought); John van Maanen (Organization Studies); and S.J. Keyser, J. Bresnan, and L. Gleitman (Cognitive Theory and Mental Representation).

Acquisition editors are Frank Satlow (Engineering and Computer Science); Laurence Cohen (Physical Sciences and Applied Mathematics); Roger Conover (Architecture and Urban Planning); Robert Bolick (Business, Economics, and Social Science); Bruce Katz (Linguistics, Philosophy, Cognitive Sciences, and Neurosciences); Sharon Basco (Popular Science); and Henry Stanton (Bradford Books). The position of health science editor was eliminated and the program is currently under review.

BOOK PRODUCTION

Under the direction of Helen Osborne, managing editor, and Dick Woelflein, production manager, the editorial and production departments produced 121 books, marked by high editorial and production standards. One of the most notable projects produced was the *Industrial Energy Conservation Manuals*, which took 1,345 hours to edit. A total of 160 books were reprinted, and production costs rose an average of nine percent.

The equipment for Computergraphics, the Press's new computerized typesetting facility, was installed in November after two years of research and testing. Under the direction of Mildene Bradley, manager, the installation test was completed in January, and composition of Press books began in February. To date, three books have been produced on the system: *When the Snakes Awake* and *How Life Learned to Live* both by Helmut Tributsch, and *Abusing Science* by Philip Kitcher. A dozen titles are in process.

The Design Department, under the management of Sylvia Steiner, continued to produce fine book and jacket designs, capturing multiple awards from a variety of organizations, including the Boston Art Directors Club, the American Institute of Graphic Arts, and the American Association of University Presses. Several books were featured in the New England Book Show.

BOOK SALES

Under the direction of Thomas McCorkle, our marketing department sold approximately 442,000 books this year: 158,000 hardcover and 284,000 paperback. Domestic sales improved by 16.2 percent over last fiscal year, largely due to an increase in sales through retail outlets, but library sales were down this year, as were sales to wholesalers who supply books to libraries.

Customer Type	Fiscal Year 1982	Fiscal Year 1981	Fiscal Year 1980
College Bookstore	$ 755,834	734,601	723,852
Retail Bookstore	1,123,638	840,103	800,906
Wholesale and Jobber	848,628	783,168	717,111
College and University Library	107,269	109,102	117,941
Direct Mail	341,545	257,450	296,295
Other	341,929	333,696	324,586
Totals	3,518,843	3,058,120	2,980,691

Paperback sales continued to improve, reflecting trends throughout the industry, and for the first time since 1978, unit sales for hardcover books improved over the previous year, in both new and backlist titles.

International Sales and Subsidiary Rights

International sales represented approximately 25 percent of total sales, down seven percent from the previous year. Economic slowdowns in both the United Kingdom and continental Europe, coupled with a loss of 20 percent in the value of the British pound, accounted for most of the decline.

The University Press Group, a consortium of five university presses, including Chicago, Harvard, Princeton, California, and MIT, opened a Tokyo sales office in January. Staffed by two Japanese nationals, the office represents the five presses in Japan, Korea, Hong Kong, and Taiwan.

International Sales, Fiscal Year 1980 - Fiscal Year 1982

	Fiscal Year 1982	Fiscal Year 1981	Fiscal Year 1980
Australia	$ 42,000	24,000	25,000
Canada	187,000	177,000	149,000
Japan	238,000	203,000	182,000
Rest of Asia and Other	94,000	119,000	106,000
Latin America	48,000	64,000	39,000
UK, Europe, Africa and Middle East	543,000	655,000	623,000
Total	1,152,000	1,242,000	1,124,000

Subsidiary rights income increased slightly, mainly due to the final royalty payment of $12,500 received from Avon to conclude their purchase of paperback reprint rights of Paolo Maffei's *Monsters in the Sky*. Other notable rights sales included serial rights to *The New York Times Magazine* for *The Le Corbusier Sketchbooks;* translation rights in Spanish, Italian, and Japanese for *A Theory of Good City Form* by Kevin Lynch; and adoptions as main selections in the Macmillan Science Book Club for *A Search for Structure* by Cyril Stanley Smith and *Revealing the Universe* by James Cornell and Alan Lightman.

Subsidiary Rights Income, Fiscal Year 1980 - Fiscal Year 1982

	Fiscal Year 1982	Fiscal Year 1981	Fiscal Year 1980
Translation rights	$34,240	$38,497	$37,400
Book club rights	18,332	18,438	12,700
Report rights	28,330	23,066	35,500
Total	$80,902	$80,001	$85,600

Direct Mail and Promotion

Under the direction of Brooke Stevens, promotion manager, direct mail income was up this year and is expected to reach $340,000 in direct sales to individuals. Through the efforts of Claire Silvers, publicity manager, book reviews in a variety of publications increased by 65 percent over last year, including nine reviews in *The New York Times.* Herbert Scoville, the author of our best-selling book (*The MX: Prescription for Disaster*) participated in over 100 television and radio interviews; authors Dolores Hayden (*The Grand Domestic Revolution*) and Joseph Pleck (*The Myth of Masculinity)* were interviewed by Phil Donahue for the Today Show and by Studs Terkel for his syndicated radio show.

Texts that did particularly well this year were the Bradford Books in cognitive science, *Technology in America* by Carroll W. Pursell, and *Hematology,* third edition, by William Beck.

THE MIT PRESS BOOKSTORE

The Bookstore, now in its second year of operation, continued to exceed the highest projections with gross sales of more than $100,000 for this fiscal year.

Ron Jensen, new manager of the bookstore, reported that this year's best-selling hardcovers were *Turtle Geometry: The Computer as a Medium for Exploring Mathematics* by Harold Abelson and

Andrea diSessa, and *Robot Manipulators: Mathematics, Programming, and Control* by Richard Paul. Best-selling paperbacks included *Mind Design* by John Haugeland; *Brainstorms* by Daniel C. Dennett; *Artificial Intelligence,* Volumes I and II by Patrick Henry Winston and Richard Henry Brown; *Buffalo Architecture: A Guide* by Reyner Banham; *Handy Farm and Home Devices and How to Make Them* by J. V. Bartlett; *Sciences of the Artificial* by Herbert Simon; and *The MX: Prescription for Disaster* by Herbert Scoville, Jr.

JOURNALS

The Journals division achieved sales and a net surplus ahead of the projected budget for the second consecutive year. The gain was $145,000 on total earned income of more than $2 million. Our journals reserve has now increased to $780,000, an increase of 30 percent over fiscal year 1981. Seven journals posted surpluses for the first time, leaving only newly initiated journals in defecit positions.

The International Journal of Robotics Research, edited by Richard Paul and Michael Brady (MIT), was launched this year, the first journal initiated by the Press since *Cell* was started nine years ago. International Organization, edited by Peter Katzenstein, a well-established and respected quarterly devoted to political economy and sponsored by the World Peace Foundation, joined the program in January 1982. The first bilingual (English and Italian) issue of the international quarterly *Spazio e Societa/Space and Society* was published this spring. Giancarlo DeCarlo continues to edit three issues of the journal, and Julian Beinart (MIT) is American editor responsible for one issue each year. Negotiations were completed at the end of the year for North American distribution rights to the new quarterly *Mimar: Architecture in Development,* edited by Hasan Khan.

One journal, *The Neurosciences Research Program Bulletin,* edited by George Adelman, will cease publication in the fall. Two journals will be leaving the program: *Oppositions,* edited by Peter Eisenman et al and sponsored by the Institute for Architecture and Urban Studies; and *Science, Technology, and Human Values,* edited by Marcel La Follette and cosponsored by the John F. Kennedy School of Government of Harvard University, and the Program in Science, Technology, and Society of MIT.

Several journals were cited by major publications, a noteworthy distinction since journals are rarely reviewed. *Choice* magazine reviewed *October,* stating, "Few, if any, journals could receive a higher recommendation for acquisition by all college libraries, and any library, with an arts clientele. For cinema studies, it is essential." Articles in *International Security* were cited frequently in *The New York Times, Wall Street Journal,* and the *Christian Science Monitor. Computer Music Journal* and editor Curtis A. Roads were mentioned in *Newsweek. Perspecta 17* was selected for the American Institute of Graphic Arts Cover Show and also received an award for distinction from *Art Direction Magazine. Cell,* edited by Benjamin Lewin, continued to win critical acclaim throughout the world, and to grow impressively. The circulation now totals more than 5,200 subscribers.

For the second consecutive year the Journals Division program staff presented the session on journals publishing at the Radcliffe publishing procedures course. Ann Reinke, manager of the journals program, continued as an active member of the Association of American Publishers/ Professional and Scholarly Publishing (AAP/PSP) Journals Committee, the Copyright Clearance Center Liaison Committee, and was elected to the board of directors of the Society for Scholarly Publishing.

FRANK URBANOWSKI

News Office

Several subjects put MIT into the national news in 1981-82, but none more so than the lengthy discussions and final consummation of an affiliation between the Institute and the newly formed

Whitehead Institute for Biomedical Research. MIT's situation was complicated by a coincidence of events. News media, at the same time, were busy reporting growth in industrial sponsorship of academic research. The problem of the News Office was to persuade reporters that while industrial support is on the rise at MIT, Whitehead -- a charitable, nonprofit institution -- ought not to be used as an example. At year's end, that problem persisted. Initially, I could report only limited success; with the passage of time, however, I think there is evidence most media are coming to understand the difference between the Whitehead affiliation and industrial sponsorship.

Industry support was the subject of a meeting during the past year of five university presidents, including President Paul E. Gray, at Pajaro Dunes in California, which drew widespread public attention. MIT's concern with growing shortages of engineering faculty and with efforts to apply Federal export restrictions to academic science also drew national attention. Other major stories with which the News Office dealt during the year included the visit of US Vice President George Bush, the SkyArt exhibition by the Center for Advanced Visual Studies, an exhibition on design aspects of contemporary clothing in Hayden Gallery, the initiation of a writing requirement for MIT students, and the Commencement address by Katharine Graham, president of the Washington Post Company. Also prominent in the media during the year was news from Professor Robert Weinberg and colleagues at other institutions about discovery of oncogenes, naturally occurring genes that appear to be involved in the triggering of cancer.

The News Office issued during the year about 180 press releases and photo stories, of which 39 related to art, music, dance, drama, etc. and 25 reported the results of research.

There were 40 issues of *Tech Talk* during the year totaling 320 tabloid pages. In addition, *Tech Talk* published four supplements: the President's Report, Committees of the Institute, Graduate Student Housing Report, and an overview of the Medical Department on the occasion of its move to the new Whitaker complex. At year's end, there were 534 mail subscribers to *Tech Talk* --315 paid individually, 219 paid by MIT, and 68 complimentary. Subscriptions (somewhat costly because *Tech Talk* does not enjoy second class mailing privileges) were down somewhat from the previous year, probably due to worsening economic conditions. The year also marked gradual conversion of *Tech Talk* from five columns to four columns.

Of particular importance during the year was discontinuance of *Reports on Research* in the form that it had been published by the News Office since 1958. As part of continuing efforts to make maximum use of available resources, the content has been incorporated into an expanded and improved *MIT Report* published monthly by the Industrial Liaison Office.

The year marked three departures from the staff. William T. Struble, assistant director, retired. Elizabeth Huntington and Caridad Sritharan resigned. Their duties have been absorbed by other members of the staff, including Assistant Directors Charles H. Ball, Robert C. DiIorio, Joanne Miller (*Tech Talk*), and Calvin Campbell (photojournalist) as well as support staff members Donna A. Harris, Lisa E. Hirsh, and Eileen J. Kennery.

ROBERT M. BYERS

Office of Admissions

This year one of the major topics of discussion for admissions officers was financial aid. The Reagan administration's efforts to reduce Federal support for students created the impression that no aid would be available for needy students. High school students and their parents expressed more concern than at any time in recent memory. In spite of all the furor, most colleges were able to meet 1982 applicant need in ways which closely approximated patterns established in previous years. In the future, the threat for private colleges will be not only the reality of diminishing funds, but also the increasing conviction among middle- and lower-income families that they cannot finance an MIT education for their sons and daughters.

The other external factor which affects undergraduate admissions is the pervasive concern -- approaching fear -- about the future job market. Engineering and, in particular, electrical engineering and computer science are oversubscribed while some disciplines are lacking in students.

Only a few years ago, applicants were more concerned about intellectual and social issues, but the driving force now seems to be job placement and security. The disparate teaching loads among departments is likely to be a source of irritation for those who feel the pressure. This problem, not unique to MIT, requires attention both nationally and at the Institute, if we are to make the best use of available resources.

In some ways, the problem is particularly acute at MIT, for many talented young men and women fail to discern the range and breadth of opportunity available to them here. We need to find ways to encourage a broader distribution of students among departments, to moderate over time the swing in numbers in each department, and to tap fully all the intellectual strengths of MIT. The discussions that have led to the Science, Technology, and Society program need a broader audience both on and off campus. High school students frequently fail to examine their decisions in light of the current trends that make for a future that will be different from the world we know today. The task in admissions, then, is to help high school students see themselves in a longer-range context and to help them gather and interpret information about higher education, thereby freeing them to make informed judgments and successfully meet new challenges.

The Institute has its own needs. Primary among them is the need to attract students of superior intellectual capacity who have demonstrated substantial academic achievement and possess the potential for intellectual independence. These students, we believe, should be characterized by flexibility of approach, a sense of commitment, a concern for others and for the fabric of our society, and leadership ability which recognizes the value of teamwork. Our task is to find these students and encourage them to consider MIT for their education. Our challenge is to reduce the considerable inertia that keeps MIT's image in the high schools tied to the realities of the 1950s. This image has served us well in the past but is not reflective of MIT in 1982. The internal tension at MIT between the traditionalists and those who would shape a different future pulls and tugs at our resolve. We believe our assignment, insofar as it affects high schools, is to project MIT as it is today and as we expect it to be five years from now. We further believe that this responsibility belongs to every member of the MIT community.

This year we have worked and will continue to work to increase the number of women and underrepresented minorities in our student body. These groups still have a great need to know that MIT has promise for them.

The anticipated computer development moved slowly and, at times, haltingly this year, but the critical deadlines were met. Our letters of acceptance were mailed on March 17, the earliest date ever. In the past when we mailed our acceptance letters after spring break, there was a significant decline in our yield. The cause of the drop is not clear, but pre-spring break mailing seems to increase the numbers who choose to attend MIT.

The Educational Council strengthened its membership by enrolling increasing numbers of female and minority MIT graduates. This year, six educational counselors received the George B. Morgan Award in recognition of sustained excellence in their work for the Council. The recipients for 1982 are: Bruce Fabens, Class of 1944; Walter Godchaus, Class of 1935; David E. Gushee, Class of 1950; Dr. Frederick J. Kolb, Class of 1938; William E. Moss, Class of 1952; and Irvine E. Ross, Jr., Class of 1930.

ADMISSIONS TRENDS 1975-82

	1975	1976	1977	1978	1979	1980	1981	1982
Entrants from Secondary Schools								
Preliminary Applications	8,166	8,104	7,853	9,320	10,274	11,223	12,526	12,769
Final Applications	4,726	5,194	4,838	4,870	5,368	5,677	5,922	5,688
Admissions offered	2,106	2,277	1,939	1,865	1,813	1,809	1,909	1,911
Actual registrations	1,154	1,044	1,073	1,059	1,059	1,081	1,031	1,109
Registrations as percent of admissions	54.7%	47%	55.3%	56.7%	58.4%	59.7%	54%	58%
Number of secondary schools represented	918	866	859	877	893	894	835	904
Percent of students from 9 northeastern states	50.8%	48%	52%	50.6%	49%	47.8%	51.9%	49.9%
College Transfers								
Total applications	879	941	1,079	1,074	1,143	1,131	818	1,006
Applications completed	499	536	591	535	486	471	399	409
Admissions offered	200	203	175	172	152	167	93	128
Actual registrations	155	162	141	123	124	119	76	95
Registrations as percent of admissions	77.5%	80%	81%	72%	82%	71%	82%	75%
Graduate Students								
Total applications	6,447	7,511	7,740	7,454	7,849	7,832	9,075	9,239
Admissions offered	2,119	2,676	2,644	2,724	2,636	2,380	2,926	2,935
Actual registrations	1,015	1,441	1,369	1,461	1,362	1,212	1,465	1,592
Registrations as percent of admissions	48%	54%	52%	54%	52%	51%	50%	54%

PETER H. RICHARDSON

Personnel Office

The reports which follow highlight the past year in the sections that comprise the MIT Personnel Office. They report a year of working within the new organizational structure implemented last year.

The office now consists of four major sections:

Compensation and Employment with the 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 of faculty and staff. The office also is 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 staff, screening and referral of candidates for positions, and development and direction of training programs.

The structure, and its staff, have been very effective in meeting the needs of the community. The objective of increasing personnel service to the community in a period of restrictive budgets was met over the past year through efficiencies within the new structure. These efficiencies must continue in the years ahead, a period in which the Institute will be facing further budget reductions.

As part of the reorganization to increase service, the Office of Child Care was linked closer to the Technology Children's Center (TCC), and the staff of the office now reports to the Director of TCC, with institutional reporting through the office of the senior vice president.

A number of changes in staffing occurred during the year. Joan F. Rice was appointed as manager of Services and Development and Dr. Isaac M. Colbert was appointed as manager of Faculty and Staff Information Services. Ms. Rice had previously been in Personnel Development while Dr. Colbert was the Institute's Assistant Equal Opportunity Officer. George Petievich left the Personnel Office, after establishing a computerized personnel system, for a senior administrative position with the MIT Medical Department. Kathy Rick, personnel officer for the School of Engineering, left the Institute to relocate. Anne Whitman, personnel officer for the Sloan School of Management, accepted a temporary assignment with the Admissions Office to work with the director on admissions policy and recruitment endeavors.

JAMES J. CULLITON

FACULTY AND STAFF INFORMATION SERVICES

The past year has witnessed continued reorganization and realignment of responsibilities within the Faculty and Staff Information Services (FASIS) organization. George N. Petievich left the Personnel Office to assume new responsibilities within the Medical Department. We shall miss his good humor and knowledgeable advice, not to mention his rapier wit! Elizabeth K. Mulcahy and Claire L. Paulding have assumed new responsibilities as assistant managers. Ms. Mulcahy will continue to oversee the functions of the Faculty and Academic Staff Records Office (FASRO). Ms. Paulding has assumed oversight of the Personnel and Employee Records Section (PERS) in addition to her responsibilities with regard to database management for the employee records system.

Additional operational and staffing changes, particularly within the Personnel and Employee Records Section, have enhanced the effectiveness of that office and have brought into closer alignment the practices and procedures of that office and FASRO.

Substantial progress has occurred in the implementation of a new computer-based personnel and employee records system. During the past year, the nascent information system progressed from a static-query configuration to one that is currently on-line and interactive. Additional terminals have been acquired and are being installed for use within the PERS, FASRO, and Benefits areas. The new system operates within the CMS and NATURAL environments yet maintains both the EASITRIEVE and ADASCRIPT utilities that were implemented in an earlier stage of development. Flexibility with respect to date-file accessibility and statistical output continues to be improved in support of the general informational needs of the Personnel operation.

Development of a new information system in support of the Wage and Salary Administration and the Employment Activity sections of the Personnel Office is under way. The immediate special needs of these sections require consideration of hardware and software configurations that are distinct from those now being implemented for the larger, more complex database management system. However, the potential for future interfacing with the larger system will remain a consideration as the new system is developed.

The word processor facility experienced a major expansion during the past year and, for the first time, is now an accessible and flexible resource for the entire Personnel Office. Its expansion enhances our ability to generate information of various sorts for the Institute community, improving the efficiency with which letters, lists, and other information can be produced.

Finally, production of the MIT telephone *Directory* has undergone a major review. Responsibility for all aspects of its production now reside within FASIS, and a number of procedural and structural changes have been introduced, with the objective of simplifying the *Directory* and reducing its cost. For the coming year a major objective will be to effect further simplifications of production to reduce the effort involved.

ISAAC M. COLBERT

COMPENSATION AND EMPLOYMENT

Benefits Administration

During the past year the Benefits Office was reorganized into three sections: Information Services, Data Processing and Records, and Retirement Counseling. The Information Services Section established an editorial board to rewrite and update approximately 30 summary plan descriptions of the Institute's benefit programs. This project, expected to take more than one year to complete, will not only satisfy the legal requirements of the Employee Retirement Income Security Act (ERISA) but will provide current, understandable information to all members of the MIT community. The board comprises members of the Benefits Office, the Wage and Salary Office, and the Treasurer's Office.

The Data Processing Section revised the annual personal statement of benefits for faculty and staff, added a new statement for those working after age 65, and began planning the conversion of the office's manual records into an electronic data system.

In response to many requests, the Retirement Section increased the number of pre-retirement planning seminars from one session to three. One of these seminars was conducted at Lincoln Laboratory for the convenience of its staff. The section also counseled approximately 110 retiring members of the community, the families of the 80 who died during the year, and the approximately 1,600 retired or disabled.

In the health insurance area we increased outpatient coverage for Institute employees under Blue Cross/Blue Shield thereby eliminating the one remaining difference between MIT's two Blue Cross/Blue Shield plans. In July 1980 we increased substantially the Institute's subsidy of health insurance for faculty and staff and added prescription drug coverage for our Harvard Community Health Plan group. The Benefits Office studied possible improvements in the Blue Cross inpatient psychiatric coverage, and surveyed area health maintenance organizations for possible additions to MIT's three current health insurance choices.

Wage and Salary Administration

The primary concern of the Wage and Salary Office is the equitable administration of the compensation structure of each of the Institute's faculty, staff, and employee groups, including responsibility for conducting all annual performance reviews. In preparation for these reviews during the past year, the Wage and Salary Office participated in approximately 30 outside salary surveys and conducted three major surveys of its own (faculty, administrative staff, and sponsored research staff). By means of these surveys, the Office was able to assess the compensation relationship of all categories of Institute faculty and staff to national and regional economic trends and to comparable, competitive markets. As a result, suitable adjustments were made to all salary scales. Performance levels and job responsibilities of more than 8,000 staff were reviewed, and appropriate merit increases were determined and put into effect.

MIT's 1982 faculty salary survey of 25 comparable universities across the country showed that the Institute's position continued to be favorable overall but that it continued to be at a relative disadvantage with respect to salaries paid to its junior faculty. As a result of this survey and other data a special effort was made, at the time of the review, to adjust the salaries of new assistant professors and to address the resulting compression effect caused by these adjustments.

The Staff Salary Administration Program continues to be both successful and flexible in its operation. More than 340 positions have been reviewed by the Wage and Salary Office since the Program's modification four years ago. Of these, 68 positions were reviewed this year, including 53 requests to evaluate new positions and promotional recommendations, largely from the exempt payroll, and 15 requests to reassess existing positions. These reviews not only resulted in the assignment of equitable salary ranges for the individuals concerned but also added substantially to our database of information concerning position requirements and responsibilities in the staff area.

Continued attention to the salary ranges of the Institute's support staff has resulted in the evolution of a competitive market position for this group relative to most Boston-area employers. Special pre-review adjustments were made in January for 106 members of the support staff to address compression problems which resulted from the substantial adjustments made to the range minimums over the past two years. The position standards developed several years ago by the Working Group for the support staff continue to be useful, fair, and workable. They contribute substantially to equitable decisions concerning individual support staff positions, particularly in cases of promotion, and to encourage the use of all ranges within the support staff structure.

Employment Activity

The nonacademic population on campus, as of June 1, 1982, was 4,850, a decrease of 390 employees from the past year. The annual termination rate for campus nonacademic employees was 17.5 percent. Employment opportunities showed a 33 percent decline in the number of positions available, averaging 147 per month. These combined factors of the Institute's employment experience parallel the tightening employment and economic conditions which have prevailed on local and national levels throughout the year. A total of 980 new openings were posted during the year. Personnel Officers interviewed 2,370 applicants, 27 percent fewer than the number of interviews conducted last year. Of these, approximately 70 percent were referred to one or more supervisors resulting in a total of 3,410 departmental interviews. From this pool over 600 new employees were hired. This represented a 36 percent decrease from the previous year's 940 hires. In addition, more than 6,000 résumés were received, reviewed, and acknowledged with personal letters. Of these approximately 4,800 were referred to departments for further consideration.

During the past year, 180 MIT employees successfully transferred into new positions within the Institute. This is a 27 percent decrease from the previous year's total of 240. An additional 220 MIT employees changed positions within their own department. The sum of all hires and internal transfers was over 1,000, a 15.2 percent decrease from the preceding year.

KERRY B. WILSON

LABOR RELATIONS

The Office of Labor Relations conducted negotiations with six of the Institute's seven bargaining units commencing in May 1981. The last agreement was signed in November 1981. James J. Culliton, director of Personnel, served as chief negotiator and was the spokesman for the Institute in the sessions with the Service Employees International Union and the Hotel, Restaurant, Institutional Employees, and Bartenders' Union bargaining units. James J. Fandel, manager of Labor Relations, acted as spokesman for the negotiations with the Research, Development, and Technical Employees' Union and the Independent Union of Plant Protection Employees bargaining units. All agreements were extended for two years with 10 percent wage increases being granted in each year of the settlements. We appreciate the interest, guidance, and commitment of the men and women who served on the Institute's negotiating committees representing a variety of departments and laboratories throughout the Institute.

Negotiations are currently under way with the Campus Police Association. Mr. Fandel is serving as spokesman for this negotiation, coordinating closely with James Olivieri, chief of Campus Police. An early and equitable conclusion to the negotiations is sought by the Institute.

The past year has been unusually active in the administration of the labor agreements. Several of the unions are attempting to administer the agreements through the use of the arbitration

process. There are currently 17 arbitrations scheduled for hearings between July and December 1982, resulting from grievance activity during the past year. The issues being arbitrated are promotions, the right to use contractor personnel, layoff rights, classification issues, working conditions, discipline, discharge, work jurisdiction, and management rights. In addition, there are eight more grievances waiting to be scheduled for arbitration. Seventeen arbitrations concerning bargaining unit work have been placed on hold by the parties. There are two issues before the National Labor Relations Board (NLRB) at the present time, both dealing with the release of information to the union under unusual circumstances.

The issue of the Institute's private property rights associated with an attempt of an outside union to organize Coop employees (some located on campus) was upheld by the state court. The Institute's position was that the Coop picketers, who are not Institute employees, could not picket on MIT property. The verdict of the courts and the NLRB on this issue has landmark significance, particularly as it relates to a similar incident at Princeton University.

JAMES J. FANDEL

PERSONNEL SERVICES AND DEVELOPMENT

Personnel Services and Development expanded the scope of service to the MIT community during a year of budgetary limitations and reduced staffing both within the Personnel Office and throughout the rest of the Institute. Efforts were made to integrate personnel officers into departmental operations so that they could be available for supervisory assistance and employee counseling on-site. Personnel officers also increased their participation in the presentation of training and development programs and assisted departments in designing special programs to meet their individual needs. Personnel officers continue to work closely with senior officers on organizational planning with particular attention given to staffing and affirmative action concerns. As in the past, Personnel officers' responsibilities include salary and classification review, personnel policy interpretation, applicant and transfer referral, personal and career counseling, and Institute representation in union matters. Statistical information on applicant and transfer referral is shown in the preceding report on employment.

In response to the training and development needs assessment which was conducted during the spring of 1981, 17 different programs were presented 35 times with 1,060 individuals participating. In addition, 750 people attended at least one session of the lecture series, Management Today, sponsored with the Sloan School of Management, and Getting to Know the Institute, sponsored with the Provost's Office. The Personnel Office continued to offer orientation programs for new employees and to coordinate the Lincoln Laboratory Equal Employment Opportunity Program. Overall, approximately 2,500 people attended programs organized by the Office. More than 80 people participated in presenting these programs, and only five were consultants from outside the MIT community.

JOAN F. RICE

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 membership of the Club now totals more than 1,500, with each member having served the Institute for more than 25 years. The annual meeting, at which new members are inducted into the Club, takes place in the spring. Other annual functions include a picnic in the summer and a holiday gathering in December. The Club also provides administrative and logistical support to the Institute's annual charitable campaign and to its retirement dinner in June.

An extensive travel program is organized for the alumni, retirees, and the Institute community offering approximately 100 departures to various destinations annually. Some of these include lecturers or other educational aspects.

There are four officers and eight directors on the board. The staff of the Club consists of Ann P. Brazier, office manager, and two assistants, M. Francis Daly and Nanci Drago. New offices were obtained for the Club in the spring and they are now located in Building 20, Room 023, offering adequate space in a more centrally located area.

PHILIP A. STODDARD

* * *

Council for the Arts

The Council celebrated its 10th year of operation in 1981-82 and saw the ground-breaking for a new Arts and Media Technology Center at MIT. Begun as an experiment in the adaptation of an arts council to an academic setting, the Council has now become a nationally recognized organization attracting cultural and business leaders of international stature who support the belief that the arts have a significant contribution to make to the scientific and technical education offered at MIT, and that MIT has an equally significant contribution to make to the future of the arts.

With the announcement of the new Arts and Media Technology Center, the Council achieved its first major step in assisting MIT with long-range planning for arts programs at the Institute. By consolidating existing arts and media activities, and through access to research and teaching in modern information technologies, the Center will create vast new opportunities for the production, presentation, and dissemination of art. Activities to be housed in the new facility include basic research, experimentation, and advanced study in the areas of computer graphics and animation, computational video, man-machine systems, consumer electronics, experimental print media, photography, film/video, electronic music, and computers in education. A particularly important aspect of the new facility is that it will afford now disparate projects in the arts and media technology the opportunity to collaborate with existing Institute programs in computer science, cognitive science, human communications, and the use of modern information systems in education. This collaboration will, in turn, augment and strengthen MIT's overall efforts in the use of computers in the educational process. Ultimately, the Center will help produce not only new creative art forms and technical applications to the publishing, broadcasting, and computer industries, but also new modes of education and research, new industries, and new ways of addressing social concerns.

Continued and increased fund-raising efforts for the Center had direct repercussions on the Council's operating budget. With over one-third of the total construction cost of the new facility coming directly from Council members or through efforts of Council members, development plans for the Council's operating budget had to be re-oriented towards new sources of support. Although fund-raising deadlines for the new Center made it difficult to meet the requisites of the Council budget, careful planning combined with new fund-raising strategies were designed to alleviate this problem in the future.

Membership

The Nominations Committee, under the chairmanship of Nelson Lees, met throughout the year to generate and review proposals for new Council members. Considerations for membership included breadth of geographic representation, a record of active support for the arts, and congruency of interest or expertise with arts programs at the Institute.

Five new members were appointed to the Council for three-year terms by President Paul E. Gray.

They are: David Bakalar, Leonard Bezark, Jr., Edna Goodrich Brown, Edmund Carpenter, and Deedee Pharr. James A. Hester, Jr., concluded his term of membership with the end of the year. The Council was greatly saddened by the death of two of its members: in November 1981, Hilda de Rothschild, an ardent patron of the fine arts, and in May 1982, Archibald MacLeish, poet, playwright, man of letters, and source of inspiration for the Council since its founding.

At the year's end Council membership stood at 96, the highest in its 10-year history.

Grants Program

The Grants Committee, composed of 14 Council members and chaired by Lewis Cabot, met four times during the year to review a total of 42 grant applications. After individual site visits and careful review of each proposal, 29 grants were awarded to MIT students, faculty, and student organizations. Almost 42,000 was allocated, which in turn generated more than $70,000 in matching funds, including in-kind contributions. In response to increased competition for Council grants, the staff scheduled more time to work with applicants on the formulation of projects, proposal and budget presentation, and the location of matching support.

Among the more exceptional projects was a collaboration between Susan Brennan, a graduate student with the Architecture Machine Group, and Gyorgy Kepes, artist and Council member, to produce an optical videodisc which enables the viewer to explore the documentation of the creative process in a highly individualistic manner. As an innovative union between the visual arts and technology, this project offers a new mode of exhibition for museums and galleries. The Grants Committee also assisted with publication costs of *The Boston Composers Project,* the first major research project concerned with detailed documentation of contemporary American musical composition. Grant funds also supported a sold-out performance by "The Art of Black Dance and Music," public lectures by author V.S. Naipaul and jazz artist Frank Foster, a performance by visiting French playwright Raymond Cousse, and the Boston premier performance of John Harbison's new composition *Variations.* Support also was given to two student publications in photography and literature, *Positive* and *Rune.* In addition, officer's grants provided smaller awards to 10 students for projects ranging from an internship in performance at the Circle in the Square Theatre in New York City to continued support of a collaborative project with the Joffrey Ballet Company.

Since the commencement of the grants program in 1974, just over $322,600 has been expended to support 185 projects, generating an additional $356,000 in matching gifts. During the past year, $41,127 was expended, which generated $70,850 in matching support.

Fund-raising Activities

The Facilities Sponsoring Committee, under the chairmanship of Vernon Alden and with leadership from Dr. Jerome B. Wiesner and Professor Nicholas Negroponte, raised sufficient funds to proceed with construction for the Arts and Media Technology Center. While fund-raising continued in an effort to meet the total project cost, construction began at the site on Ames Street. To date, the Institute has received commitments for more than $19 million of the estimated $25 million total project cost. Of the 76 gifts and pledges, 22 are from Council members, and $7 million are directly attributable to Council members and their efforts.

Under the chairmanship of Gregory Smith, the Development Committee attempted to meet the largest budget in the Council's history while simultaneously encouraging major donors to contribute to the new facility. Sixty-four percent of the Council membership made gifts to the Council's operating budget, which was supplemented by gifts from alumni and support from the Institute. Altogether, 75 percent of the Council membership made gifts to arts activities at MIT.

Additional funds of almost $40,000 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 were gifts from the Karmazin Products Corporation to support a music project in the Research Laboratory of Electronics and from the Louis B. Mayer Foundation to support a weekly public screening series presented by the Film/Video Section. Council member Alan May established an endowment to cover framing costs and acquisition of pictures for the Student Loan Collection, and another donor agreed to double an existing endowed scholarship fund to provide scholarships for private music lessons.

Publications

The Council combined its monthly calendar and quarterly newsletter into one publication which appeared once a month during the academic year. "The Arts at MIT" is the only publication at the Institute which consolidates information about the full spectrum of MIT arts activities, curricular and extracurricular. Articles feature Council members, grants projects, and MIT artists, art programs, and art activities. Circulation is over 5,600 and includes Council members and friends, MIT faculty and administrators, local community organizations, and many alumni.

A third issue of "*MIT Art in the News*" was compiled for distribution as a special fall 1982 supplement in *Tech Talk*. As a sampler of national news clippings describing MIT art activities, it will serve to publicize the breadth and quality of MIT arts programs and artists within and beyond the MIT community.

Special Events

President Gray welcomed a record number of Council members and their spouses to the 10th annual meeting, held in Cambridge on November 20, 1981. He not only reflected on past accomplishments, but also looked ahead and charged the Council membership to strive in the coming decade to build a true partnership between the arts and education. MIT Professor Henry A. Millon, dean of the Center for Advanced Study in the Visual Arts at the National Gallery of Art, built on Dr. Gray's theme of a partnership between the arts and education in his ensuing address. Professor Millon argued that the visual and performing arts are languages equally valid and illuminating as our verbal, mathematical, and scientific languages. The implications of this notion mean "nothing less than restructuring educational curricula from pre-kindergarten through the university to ensure that identified languages are given equal emphasis."

Seven groups of Council members convened with faculty and students at luncheon/workshop sessions to explore MIT art activities in studios and laboratories throughout the Institute. The workshops included: Film/Video at MIT with Professor Richard Leacock; Theatre as a Living Laboratory with Professor Robert Scanlan; Large Format Portraiture with Professor Starr Ockenga; Graphic Design and Telecommunication with Professor Muriel Cooper and Bernd Kracke, fellow at the Center for Advanced Visual Studies; Pastoralism and Modern Industrial Society with Professor Leo Marx; Figurative Sculpture at Hayden Gallery with Director of Exhibitions Kathy Halbreich; Dancing Images, an Interactive Theatre Set, with graduate students Ann Marion and Scott Fisher; and Building, Creating, and Making the Built World with Professor Jan Wampler.

During the afternoon session, the Council's theme of "The Many Disciplines, the One Imagination" was illustrated by three presentations on topics related to the arts. Professor Barry Vercoe spoke on performance and technology and presented examples of work from the Experimental Music Studio; Professor Heather Lechtman described her innovative research in autoradiography, a technique enabling art historians and conservators to reveal and examine the many layers of a painting, including preliminary sketches and work lost on re-used canvas. Professor Walle J. H. Nauta, a leading neuroanatomist, described the complex relationships of art, imagination, and the brain.

In the evening, the council met at the Faculty Club for the Annual McDermott Award Dinner. I.M. Pei accepted the eighth McDermott Award for its recipient, the sculptor Henry Moore. Art historian James Johnson Sweeney spoke of Moore's work and his connection to the Institute, followed by a short film, illustrating Moore's masterpieces in sculpture.

For its program of regional events, the Council initiated a series of "salons" this year, hosted by members in Boston, Chicago, and San Francisco. These occasions feacure MIT artists and planners presenting current arts projects at the Institute. Twenty to 40 guests assemble for an informal program follwed by dinner. At the opening salon on October 27 at the home of Council member Lewis Cabot, Sarah Caldwell and Professor Leacock discussed their recent collaborative efforts with the Boston Opera Company. Council member Ernest A. Grunsfeld hosted another salon at the Tavern Club in Chicago on March 23, with Dean John de Monchaux of the School of Architecture and Planning and Ms. Halbreich discussing MIT's innovative artist/architect collaboration on the new Arts and Media Technology facility. On March 30, Council member John O. Merrill, Jr., hosted a salon at San Francisco's Symphony Hall, with Professor Harbison introducing his opera *Full Moon in March*.

At the invitation of Council member Angus MacDonald, the new Chairman of the National Endowment for the Arts, Francis Hodsoll, visited MIT on May 25. Following a press conference in Hayden Gallery, Howard Johnson, chairman of the MIT Corporation, and the Council hosted a dinner at the American Academy of Arts and Sciences for more than 75 Boston-area leaders in the arts and education. Following remarks by Dr. Wiesner, chairman of the Council for the Arts at MIT, Mr. Johnson introduced Mr. Hodsoll, who gave a formal address and responded to questions concerning Federal arts policy.

Academic Liaison Program

The administrative staff of the Council has been increasingly called upon to assist with long-range planning projects, policy issues, and arts management services. Most recently the staff has handled negotiations between MIT and Center Screen, Inc., and the University Film Study Center involving issues of Institute space, financial responsibilities, and program development.

Council efforts also ensured continued Institute participation in the Boston Museum of Fine Arts' group membership program. All MIT students are thereby entitled to free admission and other Museum privileges. In the year since the Council initiated the program, more than 9,500 visits have been made to the Museum by MIT students.

Council staff are represented on a number of Institute committees, including the Committee for the Visual Arts, the Shakespeare Ensemble, the Lobby Seven Committee, and the Compton Gallery Committee.

During the Independent Activities Period, the Council sponsored a presentation entitled "Drawing as a Language" given by Donald Firth, executive vice president for technology development and application for TOSCO Corporation. Faculty, staff, and students attended from a broad spectrum of MIT departments and programs.

In an effort to recognize and celebrate art, artists, and art activities at MIT, the Council established the Jerome B. and Laya Wiesner Student Art Awards in 1979. The awards are given annually to individuals and organizations that have contributed significantly to the MIT community through the arts. At a ceremony on Convocation Day, May 12, Dr. and Mrs. Wiesner presented awards to Harry Newman, Class of 1982, for innovative talent in theatrical production, and to the Festival and Concert Jazz bands.

Staff Transitions

Peter Spackman announced his resignation as executive director of the Council, a position he has held since the Council's inception in 1971. Deputy Director Deborah A. Hoover was appointed as his successor. Stacia Zabusky became the Council's secretary and administrative assistant.

DEBORAH A. HOOVER

Vice President, Financial Operations

For the first time in six years the financial operations of the Institute were not in balance, with expenses exceeding income by approximately $2 million. The results for the year were not a surprise, as the Institute administration had been forecasting a $2 million operating gap for many months. Although the rate of inflation has dropped in the past year, and this will be of great significance in future financial operations, there were several other factors which impacted heavily on the expense side of the ledger. The need to improve our salary position to remain competitive with sister institutions as well as the outside world of industry and commerce, particularly in the area of faculty salaries, has been apparent for some time and substantial strides were made in these areas in fiscal 1982. The need to develop new programs to continue our position of leadership was never more apparent and this requirement drives up the expenses. In addition, the building program, which was a key part of the recent capital campaign, called for additional unrestricted revenues. Finally, the need to continually upgrade and renovate the older buildings imposes an additional burden which has to be met. Taking all of these factors into account, the MIT administration chose to go forward to meet these needs with a full recognition that some funds functioning as endowment would need to be called on to fund the year's operations.

Sponsored research, while not doing as well as we had predicted a year earlier, increased by four percent over the previous year, and viewed in the light of the Federal budget problems, this small increase in volume is not surprising. MIT was not immune from cutbacks in some areas, but on the other hand had other areas which did very well. So when looked upon in the overall sense, the support of sponsored research can still be described as very good. The outlook for the future holds promise that Federal support will continue at a reasonably good rate. In addition, there has been progress in achieving greater support of sponsored research from the private sector.

With respect to the state of the overall partnership in research between the Federal government and the colleges and universities, the year ended with excellent progress on many fronts, although there is still one ominous cloud on the horizon. The Federal Office of Management and Budget revised its Circular A-21 on cost principles to provide much greater flexibility in its requirements for faculty effort reporting, and provided as well for the reimbursement of interest costs on borrowed capital for the construction of new buildings, major renovations, and, under certain conditions, the acquisition of new equipment. The Department of Health and Human Services is attempting to reduce its auditing presence on college and university campuses which should reduce the tensions which have grown up over the last 10 years, and this is now in the process of being worked out, we hope to the mutual satisfaction of each of the parties. The Federal government also recognizes the need for an upgrading of scientific instrumentation in university research laboratories. A solution to this problem is now being sought, although this will continue to be difficult in the light of the present Federal budget situation. The one strong negative factor in the relationship with the Federal government is the present proposal of the National Institutes of Health to reduce its reimbursement of the indirect costs of its sponsored research in universities from 100 percent of allowable costs to 90 percent of such costs. Should this be carried out, it will impose extreme hardship on all universities receiving grants from that agency. Such a proposed action is unreasonable and arbitrary, and MIT is one of the leading universities in educating those involved in the Federal government to the unfairness and capriciousness of following through with such a proposal.

In the area of student financial support, the intentions of the Federal government are to reduce the rate of growth of that support and to change eligibility requirements in a way which will require less Federal funding. The results of such efforts are not yet in, but it is very likely that the impact on MIT will not show up severely at least until fiscal 1984 because of the forward funding of student financial aid programs. Thus, whatever actions are taken as part of the 1983 Federal budget will not impact heavily until the following fiscal year.

STUART H. COWEN

Office of the Comptroller

During fiscal year 1982, two major payroll systems were successfully implemented. The Service Staff Payroll became operational with the first payroll in January 1982 and the new Support Staff Payroll on June 25, 1982. Both systems have been well received by Payroll Office personnel and the MIT community. The investment in current technology has yielded a significant reduction in the effort required to produce the payrolls. Development will continue on the remaining payrolls during fiscal year 1983.

The Lincoln Laboratory Fiscal Office installed an IBM System 38 to replace its 10-year-old System 3. The System 38 is designed for, and has the software support for, a database system of operation. Conversion of all of the programs used on the System 3 was accomplished through an IBM-supplied program. Work is now progressing to more fully utilize the database capability and to expand its use into other administrative areas of the Laboratory.

The Audit Division was engaged in its continuing task of verifying the implementation of management policy and procedure, the maintenance of internal controls, and the safeguarding of assets. Audits of departments and functions showed that units are operating according to MIT guidelines and within prescribed contractual and budgetary limitations. Audits of administrative units indicated that internal control procedures are adequate and functioning as intended.

Audits of inventories, receivables, and cash (or equivalents) evaluate the control and authorized use of MIT's assets and also determine valuations for annual statement presentations. These reviews and tests enable the Audit Division to identify and correct errors or omissions, offer recommendations for improvements, and verify implementation of findings and recommendations proposed by other groups performing reviews at MIT.

Personnel Changes

The following staff changes occurred during the past year: In September 1981, Robert M. Slauzis was appointed staff accountant. In November 1981, Francis T. Conroy was promoted to audit supervisor, Marjorie E. Sciulli was appointed staff accountant, Loree A. Mahoney joined the Comptroller's Office as staff accountant, and Robert E. Travis joined the Comptroller's Office as staff accountant. In January 1982, Donna L. Dudley was appointed staff accountant and Donald E. Brown was appointed staff accountant.

PHILIP J. KEOHAN

Office of the Director of Finance

For the first time since 1975-76 the Institute had to use capital to balance the operating budget. Since the ability of the Institute to adjust rapidly to changing patterns of support while maintaining excellence in its academic programs is limited, a shortfall in operations had been approved as a part of the current year's budget. The actual shortfall for 1981-82 was $2.1 million, which compares to the projected deficit of $2.5 million in September of 1981. A program to bring operations back into balance was begun during the year and is now well under way.

The year started with interest rates at record highs and inflation hovering at the double-digit level. As the year progressed, both interest and inflation rates moderated. The cost of energy remained relatively flat during the year, and this was an important factor in the reduction of the original deficit.

Total operating expenses in 1981-82 were $515,428,000, an increase of 8.2 percent over the 1980-81 total of $476,337,000. Total operating revenues and funds used to meet these expenses rose to $505,941,000, an increase of 7.8 percent over the 1980-81 total of $469,474,000. The additional need for unrestricted revenues and funds required to bring operations into balance was $9,487,000 in 1981-82, compared to $6,863,000 in 1980-81. This requirement in 1981-82 was met in part from current-year revenues of 1) $2,773,000 from the net Use of Facilities Allowances derived from sponsored research programs, 2) $904,000 from Patent Revenues, and 3) $3,783,000 from Unrestricted Gifts, Grants, and Bequests. These sources totaled $7,460,000 leaving a shortfall of $2,027,000. This shortfall, which was less than .5 percent of operating expenses, was met by the use of reserve funds and a draw down of funds functioning as endowment.

Operating expenses for instruction and unsponsored research increased by 17 percent, the direct expense of departmental and interdepartmental sponsored research increased by 4 percent, and the direct expenses of Lincoln Laboratory increased by 5 percent over the previous year. The joint expenses applicable to instruction and research increased by 10 percent. The differential rates of growth between instruction and sponsored research were, in part, responsible for the shortfall in operations.

Another contributing factor in the shortfall was the growth of unrestricted funds required for student aid. Total undergraduate scholarships in 1981-82 were $11,105,000, an increase of 24 percent over the 1980-81 total of $8,984,000. The unrestricted revenues required to support these scholarships in 1981-82 was $3,131,000, an increase of 67 percent over the $1,870,000 required in 1980-81. The large increase in unrestricted funds resulted primarily because new sources of scholarships have not kept pace with the inflation-driven expense of an MIT education and, to a lesser degree, from changes in the funding of Federal programs.

The book value of educational plant was $278,949,000 at June 30, 1982, up from $262,658,000 at June 30, 1981.

The new dormitory for undergraduates at 500 Memorial Drive was completed and occupied in the fall of 1981. The new building for the Whitaker College of Health Sciences, Technology, and Management and the Medical Department Health Services Center was completed to a point which allowed partial occupancy to begin in late winter. Completion of the facility and full occupancy is scheduled for the first quarter of fiscal 1983. The Solar Demonstration Building was also completed during the year.

Two major new construction projects were initiated during the year for the EG&G Education Center and the Arts and Media Technology Facility.

Major renovations continued to take place throughout the campus in support of both teaching and research activities. The work on the buildings at 190 Albany Street for the Plasma Fusion Center and at 50 Memorial Drive for the Sloan School of Management were begun during the year. Major renovation projects completed during the year include the buildings at One Amherst Street, an office and laboratory building occupied primarily by the Energy Laboratory; 70 Memorial Drive, occupied by the Program in Science, Technology, and Society and the Sloan School of Management; and an additional section of 265 Massachusetts Avenue, used by the School of Architecture and Planning. In addition, the buildings at 265 Massachusetts Avenue and 42 Carleton Street were purchased for academic use.

Staff Change

During the year Doreen Morris, a budget officer in the Fiscal Planning and Budget Office since 1978, resigned to accept a position as the Financial Officer in the School of Science.

JOHN A. CURRIE

Office of Sponsored Programs

For fiscal year 1982, the total volume of sponsored research performed on campus approximated $192,725,000, an increase of 4.8 percent over fiscal year 1981 volume of $183,970,000.

Although MIT narrowly escaped the impact of unanticipated rescissions in a number of major Department of Energy (DOE) programs for fiscal 1981, the elimination or cutback of DOE programs for fiscal 1982 did affect the Institute, particularly in the Energy Laboratory and the National Magnet Laboratory. As a result, the level of DOE research support at MIT declined by 7 percent from the plateau it had reached in fiscal 1980 and 1981.

Of the major Federal agencies, only the level of research supported by the Department of Defense increased in real terms, as did the level of research funded by industrial organizations.

CAMPUS RESEARCH VOLUME BY SPONSOR

(in thousands of dollars)

	1968	1978	1979	1980	1981	1982
Department of Defense (DOD)	17,285	13,694	15,223	19,183	23,011	27,429
Department of Energy (DOE)	9,841	32,338	42,005	50,004	49,562	46,283
Department of Health and Human Services (formerly DHEW)	7,843	18,855	22,061	25,320	29,175	30,911
National Aeronautics and Space Administration (NASA)	6,170	8,064	9,505	9,295	10,525	11,053
National Science Foundation (NSF)	7,073	21,832	23,469	25,055	29,913	29,776
Other Federal sponsors	1,711	7,363	8,727	9,554	10,211	11,811
Total Federal Sponsorship	49,923	102,146	120,990	138,411	152,397	157,263
Industry	2,148	6,745	8,151	13,058	17,164	19,695
Foundations and Other Nonprofits	3,159	7,917	9,538	9,654	11,614	11,699
Other	598	2,466	2,627	1,999	2,795	3,313
Total Non-Federal	5,905	17,128	20,316	24,711	31,573	34,707
Total Research Volume	55,828	119,274	141,306	163,122	183,970	191,970

SIGNIFICANT DEVELOPMENTS

As in past years, a variety of continuing developments and new events had an impact on the MIT sponsored research program. Among these were the following:

Export Controls

In fiscal 1982 the issues involved in applying export control restrictions to teaching and research activities conducted by American universities remained largely unresolved. The International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations (EAR) administered by the State and Commerce departments, respectively, were still undergoing revisions intended to clarify their application to university research and teaching activities. At year end the Department of Defense (DOD) had not yet published its list and descriptions of the critical military technologies to be controlled. At the invitation of the Under Secretary of Defense for Research and Engineering, a joint University/DOD Forum was established to explore a broad range of mutual concerns, with export controls one of the early items on the agenda. The Defense Science Board Task Force on University Responsiveness to National Security Requirements recommended that the focal point for controls be the DOD contract, with the terms governing release of information to and participation of foreign nationals on research contracts to be negotiated by the parties. It is expected that the Forum will establish the policies under which this recommendation will be implemented.

The Whitehead Institute

On February 4, 1982, MIT and the Whitehead Institute for Biomedical Research signed an agreement setting forth the principles and undertakings on which their affiliation would be based. The agreement covers MIT participation in Whitehead Institute governance; the appointments, responsibilities, and compensation of joint faculty; financial commitments and funding; patents and intellectual property rights; the facilities and support services to be provided by MIT; and the coordination and comparability of objectives and policies. It is presently anticipated that the Whitehead Institute Building will be ready for occupancy in late 1984.

Industrial Research Support

Research sponsored by industrial organizations exceeded $20 million in 1982. The growth included not only conventional, short-term, and single-sponsor projects, but also consortia and long-term institutional agreements providing umbrella support for individual projects selected annually. The most recent example of the latter is an agreement signed in June of 1982 with W.R. Grace & Company, which will provide $6 million to $8.5 million at MIT over the next five years for research in microbiology.

Office of Management and Budget (OMB) Circular A-21

As anticipated in last year's report, substantial effort was devoted in fiscal 1982 to refining the guidelines and solving specific problems likely to arise with the July 1, 1982, conversion of sponsored projects from a salary and wage base for the collection of indirect costs, to a modified total direct-cost base, as required by earlier revisions to the Federal cost principles contained in OMB Circular A-21.

Two more welcome changes to OMB Circular A-21, however, were the resolution in fiscal 1982 of the national controversy over the A-21 requirements for reporting 100 percent of faculty effort, and the revision, announced after the close of the year, which provides that the cost of interest paid to external parties is an allowable charge to grants and contracts associated with new buildings; the major reconstruction and remodeling of existing buildings; or

with capital equipment -- acquired, completed, or fabricated on or after July 1, 1982. This provision could have a significant impact on the ability of MIT and of individual research projects to acquire or replace scientific equipment or research facilities.

PERSONNEL CHANGES

During the year the following staff changes occurred in the Office of Sponsored Programs: Effective September 6, 1981, Maureen Kelleher, assistant director, left MIT to go to graduate school, and on September 30, 1981, John F. Doyle, assistant director, left to enter the private practice of law. On February 15, 1982, David B. Foster transferred from Campus Police to OSP as assistant contract administrator. On May 31, 1982, James E. Grayson, assistant director, left to become director of grants and contracts at the New England Medical Center, and Martha R. Newton, assistant contract administrator, left to go to graduate school.

GEORGE H. DUMMER

Student Financial Services

STUDENT FINANCIAL AID OFFICE

Last year's report sounded an ominous knell for student financial aid, as the Federal program histogram peaked and began its descent. Its passage through 1981-82 left the marks of a preliminary, tentative, first-attempts cost-cutting program devised by a conservative but conscientious Congress. The cuts actually experienced in two Federal programs were modest, MIT's participation in two others actually increased, while in the fifth program a significant drop in funding did occur.

Grant Programs

As a direct result of earlier congressional budget cuts, the amount of Basic Educational Opportunity (Pell) Grants received by MIT students dropped for a second year, from $920,000 to $870,000. But the vagaries of the allocation formulae governing the Supplemental Educational Opportunity Grants Program provided an increase, from $1,140,000 to $1,300,000. ROTC scholarships remained steady at $2,450,000, $641,600 of which went to needy students. The endowment for scholarships was increased by $1,101,339, and the total income generated from this source for scholarships and grants in fiscal year 1982 was $3,299,809. The most significant change occurred in the unrestricted funds allocation -- this item moved past the $2,000,000 mark for the first time, reaching a level seven times that of 1975. Outside-agency awards again increased (to $1,220,000) and gifts for current increased slightly to $524,000. Another $755,000 in outside scholarship awards was received by students without respect to need.

Loan Programs

The Guaranteed Student Loan Program occupied center stage among Federal aid programs. During the latter part of 1980-81, Federal administration proposals for severe cutbacks in this program, that would become effective on October 1, 1981, drove many students to apply for this aid during the summer months of 1981. The total borrowed by MIT students under the program rose from $10 million to $12 million during the past year, most of it being obtained in June and July of 1982. About $310,000 of this total was loaned by MIT, the remainder by commercial lending institutions. Paradoxically, the cutbacks to the GSL program that did come about in 1981-82 were modest, and little real savings of Federal dollars resulted. Thus new proposals, of greater severity, were put forth to the Congress during the latter part of 1981-82, and at the close of the year the future character of the GSL Program was uncertain.

The National Direct Student Loan Funds Program was cut by 25%, requiring a significant reduction in the per-student loan that MIT could award -- from $1,200 to $900.

The Technology Loan Fund was tapped for loans totaling $1,353,300, including the $310,000 in Guaranteed Student Loans made by MIT.

Student Employment and the College Work-Study Program

Student employment during 1981-82 was again affected by the widespread availability of Guaranteed Student Loans. The number of students working remained constant, but they worked fewer hours. Total earnings by needy students rose only 2 percent over earnings in 1980-81. That rate does not approach the 17 percent increase that was effected in the on-campus minimum wage. We believe that this demonstrates the strong dependence by our students on the Federal loan programs.

The College Work-Study Program was cut again by 10 percent for fiscal year 1982. Funds from the grant were used almost entirely to subsidize on-campus student employment at the Institute, with half of the total grant going to undergraduates and the other half subsidizing graduate students.

Prospects

The view along the horizon continues to be grim. The threat of inexorable reductions in Federal grants, loans, and work-study subsidies will persist, with greater or lesser translation into reality as long, at least, as the nation's economy continues strained. MIT is taking what steps it can to reduce the rate of increase in the cost of the financial aid program. A significant step was taken in fiscal year 1982 collectively by the presidents of MIT and Ivy League schools, to review the parameters and cost of the financial aid programs at the nine schools. Already in the spring of 1982 some schools were altering their basic policy statements concerning aid. At the same time, efforts are being redoubled to realize alternative aid resources. These serious matters will occupy MIT throughout the coming year.

BURSAR'S OFFICE

Student Accounts

Several major improvements were made in this area during the past year.

1) In January we began to operate a new Student Accounts Electronic Data Processing System with greatly expanded information storage and retrieval capabilities. It is superior in the following ways to the system it replaces: it can be updated daily, rather than weekly; its database is tied to the Registrar's, assuring vital continuity between the two systems; it will display a student's complete financial history over an entire academic year, rather than just the current semester; and its files can be accessed much more readily for periodic analysis or research. Statements are now issued monthly, increasing cash flow to the Institute.

2) The Institute's operating budget is based upon receipt of payment for tuition and other charges on particular dates in August and January of the academic year. To the extent these payments are received later, we experience a loss in expected revenue which contributes to a budget imbalance. This year, as in the past, we have attempted to minimize this effect by charging a flat fee of $50 for the option of paying each term's charges in installments (the Deferred Payment Plan) and a separate $50 fee for each late payment.

Preparations are now complete which will allow us to implement a new Bursary Payment Plan for fall term 1982. Under this plan we will assess a finance charge in proportion to the actual amount of the bill not paid when due, an approach which, compared to a flat fee, more fairly assesses the student or his or her family for their particular contribution to MIT's revenue shortfall.

3) In conjunction with the Committee on Academic Performance (CAP) and the Committee on Graduate School Policy (CGSP), we have improved the procedures for the withdrawal of and for the withholding of degrees from students who are financially indebted to the Institute. With regard to the first of these, increased communication between the Bursar's Office and other departments has resulted in a dramatic decline in actual withdrawals. Only 48 students were withdrawn for financial reasons in spring 1982, as compared with 217 students in spring 1981. With regard to the second new procedure, we expect it to further reduce the number of students leaving the Institute with degrees while still owing substantial account balances.

Student Loans

Student loan notes receivable amounted to $31.3 million at the close of the fiscal year, an increase of 2.3 percent. These notes are funded by $8,240,000 of MIT loan funds established by friends and alumni of the Institute, $16,610,000 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 $950,000 from Institute investments.

MIT established a Parent Loan Program (PLP) in 1977 to assist the parents of our students receiving little or no financial aid in paying the cost of education. The program has grown each year and now totals 436 active accounts with an outstanding balance of $1,682,000. A total of $1,860,000 was disbursed during the year and the principal collected totaled $1,274,000.

Staff Notes

Paul L. Bergonzi resigned as Assistant to the Bursar for System Integration and Control to accept a position in the Comptroller's Accounting Office. George T. Plew was promoted from Accounting Assistant to Assistant to the Bursar.

JACK H. FRAILEY

Senior Vice President

This past year saw the completion of several major construction projects including 500 Memorial Drive, an undergraduate dormitory; One Amherst Street, a research facility; and 70 Memorial Drive, an office and classroom building. In addition, the Whitaker College of Health Sciences, Technology, and Management and the new Health Services Building were nearing completion at year's end. Construction on three other projects was initiated: the Arts and Media Technology Facility, EG&G (Edgerton, Germeshausen, and Grier) Education Center, and the expansion of facilities at the MIT Endicott House in Dedham.

With the addition of 500 Memorial Drive, our undergraduate housing need is essentially satisfied, so that attention this past year was directed at the need for additional graduate student housing. As a first step, approval was given to convert 350 Memorial Drive, the old infirmary, into a house for single graduate women. Design will be initiated early in the next fiscal year.

A study of the use and condition of Walker Memorial as related to its dining functions was completed during the year. The two major conclusions were that the commons program envisioned in the Kassakian Report for East Campus and Senior House residents could not be effectively conducted in Walker in conjunction with a la carte dining for the rest of the community, and that the kitchen facilities in Walker should be upgraded in any case. In view of the above, approval was obtained to install kitchens in the East Campus parallels and in Senior House.

Following are the individual department reports.

WILLIAM R. DICKSON

Campus Police

The MIT Campus Police Department continued to serve the MIT community with 24-hour professional police and emergency medical services. A wide range of specialized assistance to faculty, staff, and students in the areas of crime prevention, consumer and legal affairs, and criminal investigations was provided by the Special Services Division.

During the year, the department received 2,119 complaints. Of these, 29 were in the crimes against persons category, with the most common complaint being assault and battery. Although no incidents of rape were reported, there was one incident of assault with intent to rape. Overall, serious crime on the campus was down 26 percent when compared with the previous year.

Larceny continues to be the most frequently committed crime, with a total lost of $52,687. However, this was the second lowest property loss amount recorded in the past five years. Extreme upswings in this figure continue to be curtailed by the department's annual crime prevention programs which maintain community awareness of crime and encourage individuals to practice crime prevention measures.

There were 43 cars stolen from MIT property, the second lowest figure recorded in the past five years. There were 103 bicycle thefts.

In the vital area of emergency medical services, the emergency medical technicians made 2,170 ambulance runs which comprised emergencies, transfers, and medical shuttles.

The escort service continued to perform a record number of escorts this year, totaling 9,275.

There were 166 arrests during the year, representing a substantial increase over the previous year and the highest number in department history.

JAMES OLIVIERI

Child Care

The Child Care Office continues to serve the MIT community by providing information and referral. The Office has undergone considerable space improvements and staff changes during the past year. Tasks were reassigned and expanded, resulting in the revitalization of the Pre-School Swim Program for 25 children, a First Aid course for Family Day Care Providers, and Commencement Day child care for 90 children. Negotiations are under way for an additional swim program to be given later this year and for handling child care for children whose parents will be attending an Institute conference during the summer. Plans are being developed for monthly workshops for providers during the afternoon hours in the Technology Children's Center and for an infant car seat exchange service.

Family Day Care

The Family Day Care Program, a home-based, child care program used primarily for infants and toddlers, continues to fill a vital need. The number of very young children needing care is rising steadily. On-campus family day care providers, mostly graduate student wives, are in great demand. A special effort is being made by the staff to recruit more licensed and qualified providers in Cambridge and adjacent communities. Provider homes are visited regularly by the staff, lending support to providers and users.

Technology Children's Center, Inc.

Technology Children's Center (TCC) offers pre-school programs on campus, serving more than 100 children each year. TCC is licensed for children between the ages of two years nine months and six years, employs a staff of 12, and continues to serve as a field placement site for students from various area colleges and universities. During the year, TCC cooperated with the MIT Center for Cognitive Science in two language development studies.

Major playground renovations have been completed at Westgate and Eastgate. New structures designed to meet the needs of children residing in both residences and those attending Family Day Care and TCC have been installed. Major grounds work has complemented the play areas which now offer opportunities for imaginative, challenging, and safe activities. The large-scale project was made possible through cooperation from various members and groups of the Institute and TCC.

Future Directions

Child care requests of various kinds and for all ages have continued to increase. The MIT Child Care Office and TCC are working together to help families secure the best possible care for their children. TCC has initiated several information and resource sharing sessions among representatives of Institute departments in order to broaden the scope of child care. New avenues for closer collaboration among existing services and child care are being discussed and promise considerable enrichment. The ongoing development of Kendall Square and the anticipated opening of the new

Stride Rite Child Care program have renewed the interest for closer contact with other employers in the area. The pooling of resources and the sharing of expertise will be the focus for future undertakings in child care.

LUISE FLAVIN

Endicott House

Endicott House was used approximately the same number of days as in the previous year. Although non-resident use of the house increased sharply, resident use dropped by 24 nights. The house was closed for one month during the summer for work on major improvements.

The house was used 272 days and 161 nights during the year. A total of 27 resident conferences was held. Of these, 14 were MIT groups, whose guests accounted for 3,864 overnights; 13 were non-MIT groups, whose guests accounted for 425 overnights. The total overnights, 4,289, averaged 26.6 guests per night of operation.

There were 138 non-resident groups, with a total of 9,621 guests. Of these, 105 were MIT groups with guests totaling 7,709; 33 were non-MIT groups, whose guests totaled 1,912.

During the year, 21,695 meals were served, an average of 79.7 meals per day of operation.

The highlight of the year was the decision by the Executive Committee of the Corporation to proceed with the Endicott House Expansion Program. The new facility will contain 24 single bedrooms, each with private bath; a conference room for 53 persons; and two seminar rooms for 25 persons each. The ground-breaking ceremony was held on June 22, 1982. Completion of the new building is scheduled for January 1983.

AIMEE PIERSON

Graphic Arts and Audio Visual Services

Work order volume and gross revenue increased for the sixth consecutive year, totaling approximately $4.4 million. This represents an increase of 20 percent over the previous year, and the greatest increase since 1968.

A TRS-80 Radio Shack Computer was purchased for use in the Mailing Department for updating Institute mailing lists. New equipment included a perfect binder, a mailing machine, and updated processors for the Offset, Mailing, and Photographic departments.

During the past year, the east campus Copy Center was temporarily moved from E52 to E51 during renovations of the Sloan School. Enlarged facilities in E52 will be completed early in 1983.

Audio-Visual has updated rental equipment with new carousels and overhead projectors for the convenience of the community.

JAMES W. COLEMAN

Housing and Food Services

Undergraduate housing resources have increased this past year with the opening of 500 Memorial Drive. This building provides accommodations for 352 students and includes a resident dining room. In addition, there is a grill/snack bar which is open during the academic year to the community on the west campus.

Goody, Clancy and Associates, Inc. completed a study of Walker Memorial. The objective was to study the feasibility of providing separate dining facilities for the students on the east side of campus, permitting them to conduct dining-related programs without infringement by the a la carte diners of the MIT community. The report illustrates, through several options, the difficulty of using this facility for these purposes. The physical placement and size of spaces, the constraints on changes within Morss Hall, and the economics of the project are the major factors which limit reaching the goal. The report does bring to the forefront the need for upgrading and replacing existing equipment and changing the facilities to permit a more efficient operation.

The final resolution of the dining issue for East Campus and Senior House residents has been determined. They have been on a "limited" commons participation until such time as the issue was resolved. Residents of these houses developed a well-thought-out proposal for placement and operation of kitchens in their respective houses. This proposal was received by the administration, and recommended to and approved by the Corporation. The student client team and appropriate administrative offices are beginning the programming and design phases. The student groups participating in the planning were honored by being chosen a recipient of one of the William L. Stewart, Jr., Awards.

The Dining Program, now completing its second year, continues to be successful. The contributions and efforts of the House Commons Committees, the Dining Advisory Board, students, and employees have kept the program on track.

In conjunction with the Safety Office, an installation program of smoke detectors to meet new fire safety codes is under way. The approximately 2,200 smoke detectors are to be installed in all dormitory rooms and apartments. Eastgate, Westgate, Baker House, and MacGregor House are completed. The balance of the system will be completed over the next year.

Campus residents received a rebate on energy costs this year. Because of the fluctuation of energy costs and availability, this component of rent expense was left floating when the rents were announced. Late in the year, a projection was made by comparing the actual unit cost, to date, with that budgeted, and adjustments were made to the residents' accounts as necessary.

HARMON E. BRAMMER

Office of Facilities Management Systems

The Office of Facilities Management Systems (OFMS) is responsible for the collection, maintenance, and reporting of data for more than 23,500 individual spaces at MIT, comprising 7.3 million net usable square feet, up from 7.0 million the previous year. Using INSITE 3, an MIT-developed space accounting system, two major updates to the space inventory were completed. Numerous special reports also were requested throughout the year. Historical facilities data were updated and distributed in graphic and statistical form, and the Building Data Report was updated, reformatted, and published for the first time since 1972.

The maintenance and production of MIT's 276 scaled floor plans continued, as did the maintenance of MIT's room numbering scheme for both existing and new facilities. The net effect of these activities was an increase in the timeliness of these plans.

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. The Consortium's first Canadian organization, McMaster University, joined this year. Each member employs the INSITE system and its associated methodology in order to manage their inventories of building space as well as to share their knowledge and experience in this area with MIT. Many Consortium members are also using the INSITE system to assist them in managing their movable equipment.

Support activities peaked again during the year, including telephone contacts from members, visits by departmental staff to members' sites, the conducting of three training courses, the publication of a quarterly newsletter, and participation of Consortium members in record numbers at the 10th annual conference at MIT. The introduction of a new two-day course in Facilities Management for Senior Executives, available to non-INSITE users, was oversubscribed and had to be repeated later in the year.

Computer Support

Of continued significance this past year was the exceptional effort of providing INSITE 3 systems support 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 continued, focusing on input from Consortium members and software vendors, in order to assure a continuity for MIT's facilities management needs.

Property Management

During the year, more than 22,000 newly acquired items of movable equipment were identified and tagged with bar code labels. An inventory of existing items of movable equipment continued and approximately 34,000 items were identified and appraised. Nearly 400 final inventories and financial reports pertaining to contracts and grants were prepared.

Almost $1.7 million (original acquisition cost) of excess Federal government equipment was acquired, along with $318,000 of surplus state equipment. Also, items of equipment and materials were acquired from the National Association for the Exchange of Industrial Resources.

Approximately $657,000 of equipment was transferred from one MIT department to another for reutilization. More than $90,000 of equipment unneeded or unusable by the MIT community was sold. 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, OFMS was responsible for presenting a Property Management Seminar. One-day regional workshops were conducted at the Georgia Institute of Technology and at the University of Utah. More than 200 attendees from the United States and Canada were present at the seminar and workshops. Speakers included staff from OFMS as well as from other universities and government agencies.

Storage Facility

The operation of the MIT storage facility at 224 Albany Street continued, providing storage to 46 departments, for the temporary six-month storage needs of the Institute community.

Silver Recovery

An Institute-wide program for the electrolytic recovery of silver from photographic solutions continued to be successful on a small scale. Feasibility studies to reclaim other precious metals used at the Institute will begin next year.

KREON L. CYROS

Physical Plant Department

Building Service and Maintenance

Services provided to the Institute community continue to increase -- with incoming mail deliveries up to 60,000 pieces per day and interdepartmental mail at about 19,000 pieces. Approximately 100,000 incoming and outgoing shipments are handled per year through three shipping and receiving areas. During the past year, 5,000 events involving 300,000 people were held on the west campus (Chapel, Kresge Auditorium, Stratton Student Center).

A survey is under way to determine the amount of deferred maintenance in the various structural areas such as masonry, roofing, and painting. Estimates will be prepared and schedules proposed for remedial work to avoid the possibility of severe building deterioration.

Building Operations

The Building Operations Group took delivery of a second generation microprocessor-based energy management system, timed to coincide with the completion of construction of several new buildings. The new system was designed and built with solid-state heating, ventilation, and air-conditioning control systems. It permits the monitoring and resetting of solid-state unit controllers via telephone-grade wire, and provides flexibility for dealing with energy control problems anywhere on the campus. A unit controller has been installed in Huntington Hall, and work is being completed on the installation of systems in the Interim Animal Facility and the new Athletic Center.

The fire alarm and watch system (AUTOCALL) has been modernized through installation of solid-state alarm transmitters in new buildings and a central monitoring computer in the operations center.

Utilities and Engineering

Interest in energy conservation continues. As a result of our efforts over the past 10 years, annual cost avoidance now stands at the $5.8 million level, an increase of five percent over the previous year. Total energy cost for the year was $11.4 million, which is slightly below the past year's level.

Fuel oil prices continued at the lower levels established in the summer of 1981. Since the price of natural gas is tied to oil, there was an appreciable overall reduction in fuel cost.

During the year, the plant made substantial progress in the Building Energy and Modification (BEAM) Program activities. Under this program, extensive modifications are being made to the environmental equipment and control systems of our energy-intensive buildings -- to both improve their performance and to reduce energy consumption. Typically, these projects recover their cost through energy savings in two to three years and may involve extensive repiping, changing of pumps and air handling fans, and converting the ducts and mixing boxes of the air distribution systems to more efficient modes of operation. Projects have been virtually completed in the Bush, Dreyfus, Information Processing Center, and Whitaker College buildings, and a fifth project at the Fairchild Building has been initiated. Plans and specifications have been developed for the Landau Building to be undertaken as funds become available, and planning work has been completed for the Green Building.

The new East Campus Chilled Water Plant went into service on schedule, and experienced its first summer of operation with a minimum of start-up problems. At the same time, loading on the Central Chilled Water Plant was increased as space change projects -- including air-conditioning systems served from the main campus's chilled water distribution service -- were installed in several areas of the main group.

A feasibility study of methods for providing cogeneration of electricity and additional steam generating capacity in the Central Utilities Plant (CUP) was completed by an engineering consultant at mid-year. The results are being reviewed within the plant organization and are being discussed with an academic advisory group and financial personnel to determine the most appropriate course of action. The consultant's report introduced some rather new and interesting concepts for future energy planning with the suggestion that clean and efficient burning of coal at the CUP may well be the most feasible course for the Institute in the decades to come.

Architecture, Engineering, and Construction

During the past year, a number of major projects was completed: the 500 Memorial Drive dormitory; 70 Memorial Drive (Program in Science, Technology, and Society/Sloan School); and One Amherst Street (Energy Lab/Sloan School). The Whitaker College of Health Sciences, Technology, and Management/Medical Services Center complex was nearing completion at year's end.

Major renovation projects completed during the year were space for the Department of Architecture on the third and fourth floors of the former Epsco Building in the north campus, and the first and basement floors in Building 35 for the Laboratory for Manufacturing and Productivity.

Major projects now under construction are the EG&G Education Center, a five-story brick building to be connected to the Fairchild Building link and Building 24; the Arts and Media Technology building on Ames Street next to the Seely G. Mudd Building; a new 24-bed residence and conference facility adjacent to Endicott House in Dedham; renovations to the basement, first, and third floors of the Sloan Building on Memorial Drive; and the Plasma Fusion Tandem Mirror Project in the Nabisco Building on Albany Street.

Projects in preliminary design include the complete renovation of Building 39 for a Very Large Scale Integration (VLSI) research facility; conversion of the infirmary building on Memorial Drive to a single graduate women's dormitory; installation of kitchen/dining rooms in Senior House and East Campus dormitories; and relocation of the Computation Center from Building 39 to the former Supersonic Tunnel Building on Memorial Drive and to a new central campus location.

Administrative Services and Telecommunications

Plans are being developed for redesigning the 10-year-old Physical Plant data processing system. The need for better management and financial information has become increasingly evident as budgets tighten.

The Institute telecommunications system continues to grow, with the total number of telephone lines or stations up to 9,340 in June; 30 years ago, there were 2,100 lines or stations. In June 1982, more than 500,000 outgoing calls were placed; 30 years ago, the comparable number was just over 100,000. There are currently four daytime telephone operators, which is the same number that MIT employed 30 years ago.

This past year, we installed 11 new electronic key telephone systems along with more than 200 associated telephone sets in the new medical services building. In addition to providing the Medical Department with improved telephone service, these new systems will, by conservative estimate, reduce operating costs by about $25,000 per year.

The Institute continued its interest in telecommunication regulatory affairs at the state level by participating as a member of an ad hoc committee to further oppose a local telephone company rate application which, if approved, would have seriously undercut an earlier Department of Public Utilities (DPU) decision. The DPU acted favorably on the ad hoc committee's arguments that the prior decision provided an equitable increase. As a result, the Institute avoided about $100,000 in increased annual recurring costs.

PAUL F. BARRETT

Planning Office

During the year, the Planning Office undertook several major planning efforts which included a study of the housing needs of graduate students, faculty, and staff. This study, undertaken for the Administrative Housing Group, will produce housing proposals for these three groups of people. A plan for graduate student housing has been completed and should be available in the fall.

A quinquennial review of MIT's transportation needs represented another major effort. The plan was presented to the Institute's Transportation Committee, and covered the full range of the personal and public transportation needs of the MIT community. It proposed specific action that can be taken to fulfill our transportation needs and requirements through 1988.

With the assistance of Dr. Albert Bush-Brown, the Planning Office coordinated MIT's efforts to address the Cambridge Historical Commission's proposals to place a number of MIT buildings on the National Historic Register. This effort required extensive preparation of reports and documentation of those buildings, and involved meetings with the Cambridge Historical Commission, the State Historical Commission, and representatives of the Department of the Interior. Our efforts in this matter were rewarded by the National Register of Historic Places which will permit MIT's continued support of sound historic preservation for the Institute's academic buildings, without undue constraints on their flexible use.

A number of projects completed this year represented milestones in the Institute's overall campus development. With the occupancy of 500 Memorial Drive, the plan set out in 1960 for the development of undergraduate residences along the Charles River on the west campus has been completed. In the 22 years since this plan was presented, there have been many challenges to the use of this land for undergraduate students. The logic of assigning this unique resource to undergraduates who spend the better part of four years on this campus prevailed, and has been executed in large measure as originally planned.

With the occupancy of One Amherst Street, the Whitaker College, new medical facilities, and the renovation of 70 Memorial Drive, major steps in the development of the east campus have been completed. With the physical linking of several of these buildings to existing academic buildings and to each other, we are encouraged by the possibility that the continuation of MIT's interconnected building system will have a chance to grow and develop in the same positive way that it has on the main campus. This principle of interconnected buildings has provided MIT with one of its greatest physical and educational assets.

New planning and development projects are under way that include almost every part of the campus. The first phase of the Sloan Building renovation was begun this past year, along with expansion of the Plasma Fusion Laboratory along Albany Street. The EG&G Education Center is under construction as is the expansion of facilities at Endicott House. Foundation work for the Arts and Media Technology building on the east campus is in progress, and steps toward the fulfillment of the Libraries' remote storage facilities plan have been taken with the opening of a new remote storage facility in a converted warehouse. Decisions have now been made for starting the VLSI project in Building 39. As a result, the computer center and a number of smaller activities will, in part, be relocated to spaces vacated by the Medical Department and the Whitaker College.

A number of studies and planning projects which cover a broad spectrum of planning needs for the campus were begun this year. Preparations for the growth of the Materials Processing and Manufacturing and Productivity centers were undertaken by the Planning Office. Also included were

a review of the Athletic Department's small-scale facilities requirements; the preparation of funding documents for 350 Memorial Drive; participation in a Walker Memorial Planning Study; preparation of a concept plan for a physical connection between the east and main campuses under Ames Street; the outline of a lighting plan for the campus; a review of MIT's demographic, physical, and financial profile through a report on growth and change at MIT; and the sponsorship of a seminar on lighting for major cultural facilities, which was conducted in cooperation with the MIT Alumni Association and the MIT Museum.

Substantial staff planning resources were invested in Cambridge and community planning efforts. Extensive reviews of zoning proposals were prepared by the city, the Institute, and other private groups. Our energies were heavily invested in planning work concerning the former Simplex Properties, including participation and review of city studies, zoning proposals, drafting MIT zoning proposals, and the preparation of a developer's kit for the Simplex Properties. The latter reflects MIT's decision to move forward with the development of this property now that the city has completed its planning studies and has proposed its general concept for the development of this area.

Major effort has been required in the Kendall Square developments to ensure that the Institute's environment is protected and that the kind of development which occurs is complementary to the Institute's community. The first office building in the new Kendall development has been occupied, a second is under construction, and major street improvements have been started which will make dramatic changes in the circulation system and physical environment of the area around Kendall Square. It is expected that the long-delayed project for the new Kendall/MIT MBTA Station will begin in the spring of 1983, thereby making it available as a completed facility at approximately the same time as the completion of the Red Line extension to the Alewife Brook Parkway.

The Metropolitan District Commission (MDC) has proposed a relighting plan for Memorial Drive. In cooperation with the city and the MDC, the Institute has sought to ensure that this major new plan will be harmonious with the Institute's lighting needs.

The fiscal condition of Cambridge also has been monitored. The passage of Proposition 2 1/2 has required major restructuring of the city's budget, and if that were not sufficient, the impending publication of the 100 percent property reevaluation plan has led to a great deal of uncertainty in the city with regard to public services and housing.

Planning issues which the Institute must be concerned about in the future include the substantially limited land resources available to MIT for its physical development; the impact of Cambridge's tax policy under Proposition 2 1/2; significant demographic changes in the Institute's population over the next 10 years; the need for variety and innovation in supplying our housing needs for students, faculty, and staff; the extension, development, and repair of the Institute's landscape; and the impact of the Federal government's interest policy on capital expenditures and its projected stimulus of new buildings for expanding activities in MIT's growth areas. A major planning issue to be faced by the Institute is the need, through appropriate administrative and academic devices, to provide the necessary time to permit intelligent planning for future development of campus facilities. Building sites can no longer be provided on short notice. The city's parking requirements, the constraints on land acquisition, and the impact on city tax revenue all point to the need for a return to the policies which provided for a more orderly acquisition and assembly of land and a more dependable pattern of development which left neither the Institute's finances nor the city's tax base unduly disturbed.

O. ROBERT SIMHA

Purchasing and Stores

A major effort during the year was the in-depth review and analysis of the procurement function as performed by the Department of Purchasing and Stores and the on-campus laboratory purchasing agencies. A comprehensive strategic planning document was prepared which proposes significant reorganization and consolidation of the purchasing offices and agencies in ways which would maximize our strengths, maintain essential services at adequate to high levels, improve the mechanics of procurement, and substantially reduce overall operating expenses.

General Purchasing Office

Purchasing activity for the year continued at the previous year's level. Major emphasis was placed on negotiating discount agreements with more of our suppliers, which resulted in a marked increase in the number of agreements and significant ongoing savings of Institute and sponsor funds.

Office of Laboratory Supplies

Combined sales of office and laboratory items and furniture and furnishings increased 61 percent over the previous year. This significant increase was the result of furniture and furnishings requirements for new and renovated buildings. Sales of office and laboratory items, excluding furniture and furnishings, increased 15 percent.

Efforts to reduce the price of purchased goods were intensified and resulted in meaningful reductions in pricing through competition and negotiation. Successful negotiations with a number of major manufacturers allowed for purchasing directly from manufacturers at distributor pricing.

Minority- and Women-Owned Business Purchasing Programs

Business placed Institute-wide under these affirmative action procurement programs resulted in the award of over $2.5 million of our business to minority- and women-owned business concerns.

BARRY M. ROWE

Safety Office

Workers' Compensation costs have decreased below the record low of last year. This has been due mainly to efforts in the Physical Plant and increased effectiveness in the Safety Office's administration of the Workers' Compensation program.

Laboratory Safety

The first published policy on identification of chemical, biological, and radioactive substances was issued this year. Chemical waste volume continues to increase, and scintillation fluid waste volume doubled over what had been estimated. A review of the hazardous waste program activity with regard to increased efficiency and economy of operation is being conducted. A major safety audit of the Chemical Engineering laboratories in the Landau Building was conducted during the year.

Education and Training

A general procedure in the event of fire was developed and distributed to all employees, and an Emergency Action Plan, required by the Occupational Safety and Health Administration (OSHA), has been developed for implementation in the near future. During fire prevention week, a major effort was conducted consisting of slide shows, films, radio messages, and *Tech Talk* articles.

Approximately 123 persons were trained in 10 CPR courses within various departments, and 12 courses were presented to MIT-related groups during off hours.

A Diving Safety Manual has been drafted.

Also this year, the Safety Office participated in the Cambridge Disaster Drill planning meeting.

Fire Protection

General contract specifications have been written for fire alarm systems. In order to comply with the Department of Public Safety regulations, smoke detectors have been installed in many dormitories. Guidelines on corridor use also have been formulated.

Physical Facilities

An inspection of the campus by the Cambridge Building Department has been completed, and certificates of occupancy have been issued for all affected buildings and rooms.

More than 200 safety reviews of alterations and renovations have been conducted.

A PCB audit of Institute transformers was made for the Environmental Protection Agency this year by an outside contractor.

Off-Campus Sites

The MMW project, a new antenna system at Kwajalein, was reviewed, and an article for the National Electric Code on solar photovoltaic systems was finalized for the 1984 code.

JOHN M. FRESINA

Vice President, Research

Francis Bitter National Magnet Laboratory

The National Magnet Laboratory performs research in condensed matter physics, solid state chemistry, and biophysics. The current program emphasizes superconductivity. High field tunneling experiments will play an important role in this work. In particular, the current-voltage characteristics of ferromagnet-insulator-superconductor tunnel junctions have recently been shown to determine the separate spin densities of states in superconductors. This technique should provide a direct measure of important many-body effects in high field superconductors. It will play an important role in our subsequent work in this area.

Superconductivity

Other recent advances in superconductivity include the following experiments:

1) Improved critical currents have been achieved in *in situ* processed multifilamentary Nb_3Sn superconductors with submicron fiber sizes. These materials were fabricated in a high temperature gradient, continuous casting system.

2) Measurements of the upper critical field H_{c2} of single Nb_3Sn materials to 30 tesla were completed. $H_{c2}(0)$ ranges from 20 to 30 tesla. No Pauli paramagnetic limiting was detected.

3) The effects of composition on the upper critical field of vanadium gallium A15 superconductors were studied at high fields. The temperature dependence of H_{c2} requires modification of the conventional theory of high field superconductivity.

Low Temperature Physics and Magnetism

The Low Temperature, High Field Facility recently began operation. It currently provides magnetic fields to 15 tesla and temperatures down to 50 mK. Measurements of the nuclear susceptibility and nuclear relaxation time of liquid ^3He have been made in fields up to 15 tesla.

Phase transitions in several magnetic materials with unusual properties were investigated in high fields. The materials are: 1) MnAs which exhibits both magnetic and crystallographic phase transitions, which compete with each other; 2) MnP, in which a Lifshitz point was discovered; and 3) Zn-doped MnF_2, in which recent predictions concerning the effects of random fields were tested.

The thermometric characteristics of carbon-glass resistance sensors, in the presence of intense magnetic fields, were investigated over the temperature range 2.15 to 320 K.

Optical Studies

A program to study optical and magnetic phenomena of a new class of semimagnetic semiconductors, such as $Cd_{1-x}Mn_xSe$, has been initiated in collaboration with Purdue and Brown universities. These materials are interesting because of a large exchange interaction of the band electrons of the host semiconductor with the magnetic moment of the Mn ions. Raman scattering has been used to study the temperature and magnetic field dependence of the spin-flip energy in $Cd_{1-x}Mn_xSe$. Mean field behavior is seen in moderate fields; at low fields, effects due to bound magnetic polarons are observed. Stimulated scattering provides magnetically tunable laser emission.

Numerical simulations have been used to study the wave functions of electrons in semiconductors which have large concentrations of donor and acceptor ions. The results indicate that electrons are strongly localized on donor ion clusters even at ion concentrations exceeding the critical Mott value.

Far infrared photoconductivity in a high magnetic field has been used to reliably identify substitutional donors in GaAs. Precision millimeter and submillimeter wave measurements of complex refractive index have been performed in low loss materials. Refractive index can now be measured to one part in 10^5.

Smectic A-smectic C and smectic A-hexatic B liquid crystal phase transitions were studied in high magnetic fields by optical means to elucidate their critical behavior.

Studies of the electrostatic fine structure of Rydberg states of low quantum number in ^{4}He in high magnetic fields using far infrared lasers have been completed and compared with theoretical work. An experimental program on the cyclotron resonance enhanced free electron laser is under way.

Several studies of optical bistability were completed in 1981-82, including: 1) cavity-less optical bistability based on the arbitrary self-action of counterpropagating beams of light, 2) dramatic enhancement of the Sagnac effect in optical gyroscopes (as well as of directional optical bistability) based on wave nonreciprocity induced by the counterpropagating waves in a nonlinear ring resonator, and 3) hysteretic behavior of cyclotron resonance under strong near-resonant pumping due to relativistic nonlinearity of the electron mass.

Magnetism in Living Systems

Magnetotaxis was observed in a species of flagellated green algae of the genus *Chlamydomonas*. The magnetostatic response mechanism of these eukaryotic organisms appears to be similar to that of magnetotatic bacteria, i.e., passive orientation by the torque exerted by the magnetic field on a permanent magnetic dipole moment in the cell. In addition, quasi-elastic light scattering and optical birefringence techniques were used to measure various physical and biological properties of magnetotactic bacteria *in vitro*. The Low-Field Group has completed a number of theoretical and experimental studies using magnetic measurements to obtain information concerning the functioning of the lungs and brain.

Nuclear Magnetic Resonance

Solid state ^{13}C and ^{2}H nuclear magnetic resonance (NMR) was used to examine phase transitions and phase equilibria in pure and mixed phospholipid bilayers. These experiments determine the dynamic properties of the lipid molecules.

Another major area of research involves development of new NMR techniques. Advances include the scaling of sideband patterns in magic angle sample spinning spectra and the development of techniques to separate chemical shift and dipolar interactions.

The recent availability of chemically synthesized DNA fragments of specific sequence, and the application of high resolution proton NMR here, has enabled Dr. Dinshaw Patel of Bell Laboratories and his colleagues to undertake an in-depth study of such materials. In particular, he has begun proton NMR measurements on DNA duplexes and their single site mutation analogs at the oligonucleotide (8 to 17 base pairs) and polynucleotide ($\sim$200 base pairs) level in aqueous solution. Conformational features of the DNA duplex have been proved from intra- and inter-base pair proton nuclear Overhauser enhancement (NOE) effects. Contact points between the antibiotics and the nucleic acid duplex were evaluated from intermolecular NOE effects. The effects on DNA duplex conformation upon the simultaneous binding of actinomycin and netrospin were also investigated.

The folding of proteins has long been of interest to molecular biologists. Dr. C.M. Dobson and graduate student David States, of Harvard University, have used high field NMR here to investigate this process. In particular, they studied the globular protein, pancreatic tryspin inhibitor (PTI) with a new NMR technique which measures interproton distances, called two-dimensional nuclear Overhauser enhancement (NOE) spectroscopy. On the basis of these experiments it was possible to delineate the specific local structural changes which occur in the vicinity of the missing 30-51 disulfide bond and to show that the intact 5-55 bond is little affected by these changes. This

improved version of high field, high resolution two-dimensional NOE spectroscopy will have a major impact on the information content which can be derived from NMR studies on proteins in solution.

Recent work has demonstrated that NMR tomography is useful for detecting diseases in the brain, heart, thorax, abdomen, liver, and kidneys. The technique is non-perturbing, non-invasive, and free of ionizing radiation. These features have aroused the intense interest of both the medical community and the commercial sector.

Under IBM support the Laboratory has begun a program to design, construct, assemble, and test an advanced NMR imaging system for research, and to place this apparatus in operation as part of a facility to be used by the biomedical research community.

Magnetic Acceleration

A pulsed induction device has accelerated a 2.2 gram aluminum ring to 1 km/sec (cannon velocity) in a distance of 1 cm. This technique is potentially applicable to reaction engines for interorbital transportation.

A helical railgun has launched gliders to an altitude of 300 feet. This technology can be scaled to the launching of full-size aircraft from naval vessels.

Magnet Technology

Considerable work has been performed on several magnet development projects. They include:

1) Long Pulse Magnet An engineering design code has been writtent to examine the possibility of generating a field of 50 T in a 2" bore for 1 sec. using the 200 MVA Alcator alternator.

2) Imaging Magnet Research The detail design of the 2 T, 60 cm bore magnet has been completed and components are on order.

3) 600 MHz NMR Magnet Development Outline designs have been prepared. Trial windings for the Nb_3Sn high field section have been made. Problems of quench protection have been examined. Superconducting joints in Nb_3Sn conductor are being developed.

4) 15 T General Purpose Superconducting Magnet This magnet will consist of 3 Nb_3Sn sections and a background coil of NbTi. The last of the Nb_3Sn coils is presently being constructed by AIRCO. Design of the background field is proceeding with particular emphasis on quench protection.

5) Hybrid Magnets Important groundwork has been done for our next hybrid magnet project. Measurements of niobium titanium superconductors at temperatures between 4.2 and 1.8 K at high fields have been completed. A model cryostat has been developed which operates at 1.8 K in an atmospheric pressure helium bath.

PETER A. WOLFF

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. These central facilities offer state-of-the-art instrumentation and their professional staff expertise to foster diverse research projects and to enhance funding opportunities by staff in many departments.

In our efforts to keep pace with user demands, this past year our Surface Analytical Facility has installed a MACS computer system, which will offer increased capabilities for control and data analysis on the scanning Auger and LEED/ESCA units. We also have completed the consolidation of the electron microscopy STEM/TEM (scanning transmission microscope/transmission electron microscope) and auxiliary facilities into the newly renovated area on the first floor of Building 13 (formerly the Machine Shop area). The consolidation of staff and equipment for this major central facility has resulted in a substantially more efficient operating mode, both for the user community and the staff of the central facility. We would once again like to thank the MIT administration for its interest in and financial support of CMSE's efforts to establish and maintain state-of-the-art central facilities that address the needs of the entire MIT materials community.

As an important component of our research program, CMSE continued the funding of seed programs during 1981-82. Our funding of seed programs has been limited by particularly tight budget constraints and many excellent proposals could not be funded. We were fortunate this past year to be able to fund seven requests for seed programs.

Except in rare instances, priority for seed funding is given to junior faculty or newly appointed faculty. Seed funds present an opportunity for the junior faculty and new staff members to develop a strong program that can either be incorporated into one of our ongoing areas of thrust programs, or can provide a strong base for a proposal for continuing support from other funding sources.

The weekly CMSE colloquia series continued through the fall and spring terms, covering a broad range of subjects in the materials research field. Sponsorship also continued of the weekly series on polymer research. Several of the central facility areas offered IAP hands-on training courses; we intend to continue this practice as a result of broad interest and participation.

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 programs, including the names and departmental affiliation of the individual faculty researchers. The research effort for fiscal 1982 represents the third year of our current three-year grant. Changes in personnel and research direction will be effected in the next fiscal year in some of the areas of thrust.

Research on Flow and Fracture in High Temperature Alloys

The thrust of this group continues to be a coordinated study of the behavior of high temperature alloys under conditions typical of service: creep and fatigue crack initiation and growth, and the role that the environment and high strains play in those processes. During the past three-year period, the interactions and collaborations between members of this thrust group have strengthened as working relations between the members have become more firmly established, and information transfer has improved through weekly group meetings and informal seminars. Collectively, this group brings an impressive amount of talent to bear on a problem of scientific opportunity and commercial significance.

The long-term needs for high temperature service make a fundamental understanding of the structural changes important. Effects of environment are of growing interest and represent a new direction of investigation of the thrust group. A program was initiated to study dislocation kinetics of the deformation of $Ni_3(A\ell,Ti)$, which is the hardening agent in the nickel base γ-γ' alloys. Studies of short cracks will be continued by forming short cracks under creep conditions and observing their growth. The overall program of this thrust group has been enormously strengthened through the study of dislocation phenomena at grain boundaries and interphase boundaries during plastic deformation.

With regard to the specific alloys under investigation, a change in focus has occurred during the past year. Initial studies of the high strength γ-γ' alloy Rene 95 have shown a disturbingly high crack growth rate. As a result, this group is now turning to alloys with a lower volume concentration of the γ' phase, as well as to the carbide and oxide-dispersion hardened alloys already under investigation.

Faculty/Department: Professors Robert Balluffi, Nicholas Grant, Regis Pelloux, Samuel Allen, John Vander Sande (Materials Science and Engineering); and Frank McClintock (Mechanical Engineering).

Structure and Properties of Microcrystalline and Glassy Alloys Produced by Rapid Solidification

This thrust group continues to maintain a balanced program with respect to the behavior of glassy alloys and microcrystalline alloys. With both classes of alloy types, there are fundamental and engineering studies under way. The particulate production facilities (which provide powders, flakes, foils, and ribbons) have been further improved to provide melt sizes of 5 kg where required; such larger melts provide more uniform compositions of final test materials, with product sizes large enough to undertake a variety of demanding mechanical tests (notch fatigue, crack propagation rates, etc.).

The group has finalized plans to build a new stainless steel atomization tank for greater impurity control and, more importantly, to permit still higher solidification rates by atomizing: a) onto a rotating disc, b) into the gap of counter-rotating rolls, and c) into mold shapes to undertake dynamic liquid compaction (for alloy performs and reconstitution of ingot structures wherein continuous, copious liquid phase does not exist).

New emphasis is being placed on alloying studies of metallic glasses to increase T_g and to improve the high-temperature strength. Deformation in the compression mode to achieve much larger strains and to study the modes of deformation will be undertaken.

A seed program has initiated study of deformation and fracture of rapidly solidified ferritic stainless steels; these studies broaden our base by looking at combinations of properties typical of the body-centered cubic metals, an area neglected among rapidly solidified materials.

Faculty/Department: Professors Ali Argon (Mechanical Engineering); and Professors Grant, Keith Johnson, Roy Kaplow, Kenneth Russell, and Ronald Latanision (Materials Science and Engineering).

Catalytic Activity and Surface Structure

During the last three years, the members of this thrust area have collaborated on research aimed at understanding the electronic structure and chemical properties of systems of catalytic importance. The focus has been on the preparation, reactivity, and characterization of platinum (surface) alkyls, and on the effect of the modification of surface morphology and surface properties on adsorbate binding and reactivity.

The physical-chemical approach to these problems at MIT makes this surface catalytic program quite distinct. During the last year this group has found, using a variety of chemical and physical techniques, that many molecules have very different structures (as well as chemical reactivities) when adsorbed on a modified surface. This group now plans to expand into a new area: the kinetics of catalytic processes at electrodes, especially those which have been chemically modified. This fits nicely into the interest of this thrust group in environmental effects on catalytic activity and adsorption. By using experimental techniques such as photoemission, electron energy loss and Auger spectroscopy, LEED, thermal desorption and electrochemistry, they will study the catalytic and chemisorptive properties of various surfaces. Theoretical work on the electronic properties, potential energy surfaces, and vibrational properties of these surface structures will be carried out in conjunction with the experimental work.

Faculty/Department: Professors Johnson (Materials Science and Engineering); Robert Silbey, Read McFeely, Edward Solomon, R. Staley, George Whitesides (Chemistry); and Frederick Putnam (Chemical Engineering).

Defects in Solids

The focus of this thrust area has been sharpened considerably by changes in research direction. One sub-area will continue their fruitful collaboration on the study of defects in amorphous and crystalline semiconductors. This past year, the research has concentrated on understanding the electronic properties of chalcogenide glasses. The defect model previously developed has been refined and generalized to include transient phenomena. There is excellent agreement between the predictions of the model and the actual experimental results. Work in this area will be further

strengthened by a program using several recently developed techniques to study defects in amorphous silicon-based films. Significant progress has been made on a new program investigating process-induced defects in polycrystalline and single-crystalline silicon, and in III-V semiconductors. These defect studies are also linked to a new program to study defects in luminescent solids.

The focus of the effort on compound semiconductor heterostructures and devices has shifted firmly to the III-V materials in the context of their application to high-speed integrated electronics and opto-electronics. At the same time, the emphasis on silicon technology and devices has increased in the last three years from a very low level of activity to about four full-time equivalent research groups. Both efforts -- in silicon and in the III-V's -- have benefited from many interactions and the common interest of the groups in the Microelectronics Laboratory and Ion Implantation central facilities. Continued growth in the semiconductor technology and device area over the next few years is expected as part of a rapidly growing research effort in Very Large-Scale Integration (VLSI) at MIT.

Faculty/Department: Professors David Epstein, Cardinal Warde, David Adler, Clifton Fonstad, Stephen Senturia, Rafael Reif, Dimitri Antoniadis, Dr. Arthur Linz (Electrical Engineering and Computer Science); Professor Marc Kastner, John Joannopoulos (Physics); and Harry Tuller (Materials Science and Engineering).

Phase Transitions

During the past three years, this thrust area has made considerable progress on a number of closely correlated basic problems dealing with order-disorder phase transitions. The central experimental themes have concerned percolation transitions in ionic crystals, the growth of micelles, the initial formation and critical collapse of gel phases, and a variety of critical and multicritical phenomena in liquid crystals.

The group is particularly strong in experimental skills, and a wide variety of sophisticated and often unique experimental capabilities are available. The activities of the group also have been enhanced by the recent addition of a theorist, who has developed a microscopic approach to phase transition problems in which the statistical-mechanical calculations are handled by quantitative restructuring and renormalization-group transformations. This is a powerful technique for determining global multicritical phase diagrams, and phase diagrams of direct relevance to experimental systems can be studied. In particular, current work on a microscopic theory of liquid crystals that exhibit a reentrant nematic phase is directly related to the experimental activities of others in this thrust area.

In the research on liquid crystals, there has been an active collaboration on the experimental study of smectic materials (which exhibit orientational and partial translational ordering), using scattering techniques (X-ray and light scattering) and high-resolution calorimetry. Work in this area has involved the critical and multicritical behavior of smectic A, B, and C phases, and interesting results have been obtained on the smectic A-smectic C, nematic-smectic A, and reentrant nematic-smectic A transitions. These results demonstrate significant difficulties with current models, and a coordinated experimental and theoretical effort will be made to resolve the basic character of the nematic-smectic A transition and related transitions involving other smectic phases. In view of the close theoretical connection between this transition and the superfluid transition in helium, the work on the dynamical aspects of critical and tricritical phenomena in He^3-He^4 mixtures will be of considerable interest.

The light scattering work on phase transitions in aqueous media has evolved from an earlier focus on critical phenomena in cross-linked polyacrylamide gels and sol-gel transitions in condensing poly-functional systems to the study of phase transitions in structures of finite size. In both the study of coil-globule transitions in single polymer chains and the study of micelles, the nature of the solvent and the extent of ionization play very important roles in determining the cooperative behavior. This work is changing some of our concepts of polymer statistics and widening our horizons in the field of phase transitions.

Faculty/Department: Professors Carl Garland (Chemistry); and Robert Birgeneau, James Litster, Thomas Greytak, George Benedek, Ahmet Berker, and Toyoichi Tanaka (Physics).

Deformation and Fracture in Polymer Composites

This thrust area has now been in existence for four years and has developed into a coherent and strongly interactive group with remarkably complementary interests. The center of gravity of the present research effort is the collaborative effort focusing on the production of special groups of block co-polymers for the purpose of elucidation of the mechanisms of plastic flow and crazing, and the study of the effects of phase morphology, interface strength, and aging on the polymer properties. Additional and closely related research also is continuing on allied phenomena in polymer composites with inorganic fiber reinforcement, concentrating on the structure, physics, and chemistry of fiber-matrix interfaces. A unique aspect of this area of thrust is the widely interdisciplinary nature of the research, combining expertise ranging from synthesis of block co-polymers to microstructural analysis, to micro-mechanical modeling of mechanical behavior. Collaborative efforts also are in progress on modification of the properties of graphite fibers by intercalation and the possible use of such fibers in composite materials.

Faculty/Department: Professors Argon (Mechanical Engineering); Robert Cohen (Chemical Engineering); Mildred Dresselhaus (Electrical Engineering and Computer Science); and Donald Uhlmann (Materials Science and Engineering).

Research Using Synchrotron Radiation

When the decision was made to build a National Synchrotron Light Source at 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. CMSE therefore seeded a new initiative on research using synchrotron radiation, taking advantage of the outstanding talent at MIT in scattering spectroscopy. Our Brookhaven port will be a joint venture between MIT and IBM researchers. 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 in order 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.

Faculty/Department: Professors Robert Birgeneau and James Litster (Physics).

MILDRED S. DRESSELHAUS

Energy Laboratory

The main purpose 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, energy supply and demand, 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.

Recent and projected operating expenses of the Energy Laboratory are as follows:

Energy Laboratory Expenditures
($ million)

Source of Funds	Actual Fiscal year 1981	Estimated Fiscal year 1982	Forecast Fiscal year 1983
US Department of Energy	$ 5.8	$ 4.0	$ 2.4
Other Government	2.2	1.5	1.6
Nongovernment	5.1	6.0	4.5
TOTAL	$13.1	$11.5	$ 8.5

As the table of expenditures shows, the largest reductions in funds came from the Department of Energy (DOE). In particular, three major DOE-supported programs came to an end in 1981 and 1982: the Advanced System for Process Engineering (ASPEN) was completed, and the major programs on magnetohydrodynamic (MHD) power generation and photovoltaic power generation were terminated by the sponsor. These changes alone meant a $3 million reduction in the Laboratory's annual expenditures. We are not optimistic about returning to earlier government support levels very soon, so we are working harder than ever to engage the private sector in research through arrangements that are innovative yet consistent with the MIT tradition of freedom of inquiry and communication.

The number of faculty associated with the Laboratory during the year totaled 60, the professional research staff 62, and participating students approximately 215 (175 graduate and 40 undergraduate students). In fiscal year 1983 we expect a personnel reduction of more than 25 percent, reflecting our reduced level of 1983 funding.

We have made several internal organizational changes in the past year. We created a new position called assistant director of the Laboratory and appointed to that position Frank McGrory, previously business manager of the Laboratory. In assuming that post, Mr. McGrory also became a member of the Laboratory's Management Committee.

In recognition of a significant new research emphasis, we established a program area called Energy-Efficient Buildings and Systems in late 1981. Led by program director Leon R. Glicksman of the Department of Mechanical Engineering, the new program brings together researchers from the Energy Laboratory, the School of Architecture and Planning, and the School of Engineering to develop new technologies with better energy efficiency, to improve our understanding of how existing buildings and components behave, and to find the best means of teaching practicing builders and architects about energy-efficient design. Five projects are under way, with the primary emphasis being the performance and structural side effects of insulation.

Our special programs that provide for industry-university cooperation and interaction with other non-MIT people and organizations have grown and changed in the past year.

The Electric Utility Program (EUP) has 22 members for the calendar year 1982. This doubling in membership since 1981 was the result of several policy changes. Eligibility for membership in the EUP -- previously limited to electric utilities -- has now been extended to include fuel suppliers, equipment manufacturers, and architect engineers. The EUP also has benefited from a new policy of MIT's Industrial Liaison Program (ILP): ILP members are now permitted to direct up to 25 percent of their ILP membership fee toward the membership fees of several MIT collegia, including the EUP. As a result of EUP workshops in 1981, six new contracts began in the past year, and funding was renewed for eight ongoing contracts. At the 1982 EUP workshops, Energy Laboratory researchers and representatives from member companies discussed environmental management, electrical systems and equipment, nuclear technology, and fossil fuel technology. Based on those discussions, proposals for cosponsored projects are being developed and will be sent to EUP member companies later this summer.

The Center for Energy Policy Research (CEPR) now has 36 associates -- organizations from the private and nongovernmental public sectors that provide financial support and participate in CEPR's energy policy research and analysis. In spring 1982 CEPR held a major meeting at which 115 participants discussed nuclear energy -- regulation and safety, international issues, and utility matters. An additional half-day session focused on recent events and likely developments in the world oil market, a continuation of discussions at previous meetings.

In fall 1981 the Energy Laboratory began work supported by a new consortium of automotive and petroleum companies that sponsors research in the Sloan Automotive Laboratory on promising new engine and fuels opportunities. Consortium members help select research topics, get prompt access to results, and are encouraged to send their personnel to participate in the work. The Consortium provides the Sloan Laboratory with a stable funding base and strengthens MIT's academic program in automotive engineering. Thus far, the Consortium has five members, two active research programs, and seven proposed research programs. Director of the Consortium is John B. Heywood, professor of mechanical engineering and director of the Sloan Automotive Laboratory.

As mentioned above, final development, testing, and documentation of ASPEN were completed in January 1982, the culmination of a six-year joint research project by the Energy Laboratory and the Department of Chemical Engineering, supported by $6 million of government and industrial funding. ASPEN is a large computer software system developed to perform steady-state material and energy balances, estimate costs of equipment, and carry out economic evaluations. At the completion of the two-year test program in September 1981, 55 companies and government groups had received the ASPEN source code, more than 27,000 runs of ASPEN had been recorded, and numerous changes to correct errors or to make minor improvements had been made in response to user input. ASPEN has now been delivered to the US DOE, which will take responsibility for distributing the program to the public.

Several new Energy Laboratory facilities were developed in the past year. A centralized, integrated laboratory complex that supports research on the health effects of fuels utilization has recently been created. The laboratory brings together facilities for sample preparation, chemical analysis, and toxicological testing. Other facilities have been developed for interdisciplinary studies of the respiratory toxicity of combustion-generated aerosols; the most recent addition is the Aerosol Characterization Laboratory, which carries out physical and chemical analyses of gases and particulate matter, thereby characterizing samples from all the involved research groups in a systematic and consistent fashion. The health effects of soot and polycyclic emissions from domestic oil burners are now being studied in a special laboratory constructed in late 1981.

The Energy Laboratory's nonexperimental staff have also been benefiting from improved facilities since fall of 1981, when they moved into their completely renovated building at One Amherst Street. The headquarters staff and several research groups now occupy two floors of the building -- a consolidation that has made it possible to centralize and expand the available computer and word processing facilities. The Laboratory's Information Center has expanded to three times its previous floor space and has acquired new microfiche and on-line bibliographic search equipment.

The following material describes the major thrusts of the Energy Laboratory's principal research areas. More information on the specific projects being performed within the Laboratory may be

obtained from *Project Summaries, July 1, 1981 - June 30, 1982.* The Laboratory's quarterly bulletin, *e-lab*, reports on current research results of general interest.

Research

The Energy Laboratory's International Energy Studies Program conducts research on economic, political, and strategic aspects of international energy trade and on the financial implications of the large reciprocal flows of wealth associated with that trade. The core of this program is long-standing research on the nature, structure, and behavior of international markets in oil, nuclear fuel, and other energy commodities, including analysis of conditions in supplier and consumer nations. New directions for research include couplings between US domestic and foreign markets, security of supply concerns and their effect on national policies and international relations, the roles of public and private sectors in dealing with supply crises, and the energy problems of the developing world.

The Utility Systems Program brings together faculty and research staff from engineering and policy science departments at MIT to analyze utility operations and growth both in the short run and the longer run. Research, writing, and teaching have concentrated on four major areas: electric utility operations and control; economics and policy decisions associated with adoption of new, generally utility-interfaced energy technologies; development of modeling tools for utility operation and utility capacity expansion analysis; and economics of regulation/deregulation of the electric power system.

The Energy Markets, Pricing, and Regulation Program conducts research on the structure and performance of the domestic system for the supply, conversion, and use of energy, and on the interactions between that system and the domestic and international macroeconomy. Current projects include research on domestic and international macroeconomic consequences of energy supply shocks and price uncertainty; wealth and income distribution effects of changing energy supply and price conditions; structure, performance, and regulation of the US electric utility industry; structure and regulation of the natural gas transmission industry; determinants of factor use and productivity in manufacturing activities, in particular the relationship between capital goods and energy; and determinants of appliance choice, energy efficiency, and use in the household sector.

The Energy Systems Assessment Program studies future energy systems options by considering a combination of the most promising technologies that may have a significant impact on the energy problems of the nation and of the world. This program has two important tasks: to construct and evaluate the short- and long-term impact of energy systems options for different societies, and to identify research and development needs and initiate projects to solve the identified problems. International cooperative activities are planned for this program.

The Energy Conversion Program emphasizes high-temperature gas turbines with related hot-gas cleanup and cooling, fluidized and electrofluidized beds, environmental assessments of advanced energy conversion systems, and MHD power generation. The fluidized bed program is concerned with developing a mathematical model for the fluidized bed combustion program and establishing a database management system for the technology. Researchers also have developed a fiber optical probe designed to measure the bubble parameters of an operating fluidized bed.

The Stationary Combustion Program emphasizes parallel modeling and experimental investigations of combustion processes of gaseous, liquid, and solid fuels in both steady and unsteady operation. 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, nitrogen oxides emission from coal-derived liquids and residual fuel oils, and spray combustion.

Research in the Health Effects Program concentrates on determining the mutagenic, carcinogenic, and respiratory toxicity of combustion-generated particulates and polycyclic compounds. A unique feature of this program is a direct linking of research teams in engineering, analytical chemistry, and the biological sciences.

The Transportation Propulsion Program is based on the activities of the Sloan Automotive Laboratory. The work includes fundamental combustion studies, internal combustion engine research, and gas turbine and burner research.

The Advanced Technology Program examines new and emerging technologies and provides support research for more near-term programs. In directed energy processes, ceramic powders are synthesized and modified using laser heat sources, and thin films are deposited by a laser-induced chemical vapor deposition process. Other programs concentrate on unique properties achievable with rapid solidification of molten ceramics and on microstructural control in materials for ceramic processing.

Research in the Environmental Management Program seems to identify and reduce the environmental impacts of energy-related facilities and includes a wide range of research projects. Current efforts include the design of cooling systems for electric power plants, transport of buoyant effluents, water management issues associated with coal development, impacts of acid rain, and environmental implications of ocean thermal energy conversion.

The Nuclear Program has the following broad objectives: to provide direct technical contributions to nuclear plant reliability and safety; to develop and/or investigate possible improvements in nuclear plant design for fuel management that could lead to reduced power costs and more efficient utilization of nuclear fuel resources; and to develop and communicate data and information that will contribute to public understanding of nuclear power.

The Energy-Efficient Buildings and Systems Program examines the behavior of existing buildings and components and seeks to develop new technologies with better energy efficiency. Examples of current projects include studies of the transfer and accumulation of moisture in the walls and roofs of structures retrofitted with insulation, heat loss from building foundations, and the insulating value and aging characteristics of closed-cell foam insulation.

The Center for Energy Policy Research gives special focus to policy research and analysis in the Energy Laboratory, with particular emphasis on making results available and useful to policymakers. With support from a wide range of US and international 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-related policy issues. The work of the Center is carried out by professional staff members from the Energy Laboratory and faculty and students from several MIT departments (with particularly heavy involvement by the Sloan School of Management and the Department of Economics). Specialists from the Center's Associates also are involved in the work.

The Synthetic Fuels Center provides a focus within the Energy Laboratory 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 research projects include pyrolysis of coal and biomass, catalytic hydrogenation reactions, and shale oil recovery systems incorporating beneficiation.

The Electric Utility Program serves to inform participating companies about ongoing MIT research activities, to identify and discuss utility needs and priorities, and to develop research projects responsive to those needs. Each year at a general seminar, MIT faculty and staff provide participants with information concerning MIT research. Then representatives from MIT and the participating organizations plan a series of workshops in areas of mutual interest. At each workshop, participants discuss their research needs and possible projects that could fulfill the most important needs. Based on those discussions, the MIT researchers develop proposals for new projects.

Publications

During the past year, 184 publications resulted from research performed in the Energy Laboratory. These included 47 reports, 66 working papers, and 71 other publications (journal articles, workshop and conference presentations, etc.). A list of reports and working papers published since 1977 can be obtained from Energy Laboratory headquarters. Also available are a new edition of the Energy Laboratory's general brochure, a 26-page document called *Interdisciplinary Research at MIT on the Health Effects of Energy-Related Pollutants: Some Programs and Plans,* and copies of *Project Summaries* and *e-lab.*

DAVID C. WHITE

Nuclear Reactor Laboratory

During the past year the Nuclear Reactor Laboratory (NRL) engaged in joint activities with eight academic departments and several interdepartmental laboratories, the Draper Laboratory, and 26 other universities and nonprofit research institutions, such as teaching hospitals. The spectrum of these joint research or teaching and training activities includes 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

Professors Clifford G. Shull and Anton Zeilinger have continued studies of neutron interferometer systems with respect to their performance characteristics and their exploitation in fundamental neutron physics studies. Closely associated with these interferometer studies are investigations carried out on dynamical diffraction by crystals. During the last year the important aspect of vibrational motion introduction to the interferometer system has been thoroughly quantified, and a new type of vibrational isolation system has been designed and tested. The present interferometer system, classified as a Laue transmission system, has been used to measure the change in neutron wave phase that is developed with rotational motion of the interferometer and is found to be in excellent agreement with theoretical predictions. A new version of an interferometer, classified as a Bragg reflection type, has been tested and found to perform as expected. Aspects of dynamical diffraction have been studied with a large silicon crystal in which both mirror surface reflection and internal Bragg diffraction processes are simultaneously effective, and a sharing of the incident neutron intensity among the two processes occurs. During the past year, three graduate theses have been prepared.

Neutron-scattering studies of polymer structure were carried out by Dr. Charles V. Berney in a collaborative project with Professor Robert E. Cohen of the Department of Chemical Engineering. This work, funded by the National Science Foundation (NSF), provided the first experimental proof that certain microsphase-separated diblock copolymers form a body-centered cubic macrolattice. Other results demonstrated a 25 percent discrepancy in sphere sizes estimated by electron microscopy and provided information on chain conformations in heterogeneous block copolymers. Five publications resulted from the work in this area.

The Medical Research group of Professor Gordon L. Brownell in the Department of Nuclear Engineering has continued studies of boron neutron capture therapy for glioblastoma. These studies have used an animal model to demonstrate the efficacy of the technique. Preliminary results are encouraging. Plans are under way to expand studies in the general area of medical imaging. The MITR-II is an essential element in these research efforts.

Professor Frederick A. Frey's group continued its studies in geochemical analysis. These projects are based upon use of the MITR-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 in Chile.

These projects currently involve three to five graduate students, a full-time research staff person, and Professor Frey. Also, several other students from the Department of Earth and Planetary Sciences use the NRL facilities for geochemical research on a part-time basis; i.e., activation analysis is not their major analytical approach. Recently, funding was obtained for a computer-based activation analysis system. This system significantly upgraded the capabilities for trace element analysis of rocks by neutron activation.

Increased emphasis on applications of the MITR-II to the life sciences has resulted in new activities in nuclear medicine. Dr. Barry W. Wessels, who is leading this new thrust, has provided a focal point for biomedical applications utilizing the MITR-II in coordination with the Harvard-MIT Division of Health Sciences and Technology, Harvard Medical School, and the affiliated Boston hospitals. Dr. Wessels and his group have embarked on three separate collaborative efforts in nuclear medicine and radiobiological research with area affiliates: 1) In collaboration with Dr. David Elmaleh, radiochemist, Massachusetts General Hospital (MGH), a novel approach of producing anhydrous F-18 ion absorbed on Al metal which has been demonstrated using the $^{6}Li(n,t)^{4}He$; $^{16}O(t,n)^{18}F$ reaction with thermal neutrons. The synthesis of F-18 TBAF provides an important intermediate compound for the production of positron emitting labeled metabolites used in PETT scanning. 2) In collaboration with Dr. S. Treves, director of Nuclear Medicine, Children's Hospital, Harvard Medical School, an Os 191 → Ir 191m generator has been developed for first-pass radionuclide angio-cardiography using naturally abundant osmium as the reactor-irradiated starting material. The Os 191 parent ($T_{\frac{1}{2}}$ = 15 days) and the Ir 191m daughter ($T_{\frac{1}{2}}$ = 5 sec) provide an efficient generator system applicable to multiple, high-photon flux heart studies for pediatric imaging at relatively low absorbed dose. 3) Dr. B. Hoop and Dr. D. Johnson of the Pulmonary Unit in the Department of Medicine, MGH, have been interested in the control of ventilation through the regulation of chloride ion in the cerebiospinal fluid (CSF) in a dog model using tracer Cl-38. Several MIT students were involved in these research activities.

During the past year the Radiochemistry and Nuclear Trace Analysis group under Dr. Morteza 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 at the NRL 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 with respect to stable isotope methodology, and of the Department of Nutrition and Food Science and the Clinical Research Center with respect to the conduct of human metabolic studies, MIT has become a national leader in this area of human nutrition. Since the inception of this program less than three years ago, the MIT group has produced about 35 publications in various scientific journals as well as several 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 (NIH), the NSF, and the US 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 scientist from the Department of Nutrition and Food Science, several full-time MIT graduate students (S.M. and Ph.D. candidates), and 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 to assist in other research programs at the Institute.

A major alloy development project for fusion reactor first wall materials was continued for the fourth year. This research is directed by Professor Nicholas J. Grant of the Department of Materials Science and Engineering, and Professor Otto K. Harling, director of the NRL. Other faculty participants were Professors John B. Vander Sande of the Department of Materials Science and Engineering and Professor Ali S. Argon of the Department of Mechanical Engineering. Senior research staff on this project included Drs. Janez Megusar, Douglas Imeson, and Marvin Lee. Three graduate students completed their Ph.D. dissertations and several others are currently doing their research on this project. More than 35 journal articles and formal reports have been completed to date as a result of activities in this project. A major thrust of this research effort has been the exploration of the use of innovative alloy processing techniques, such as rapid solidification from the melt, for the purpose of developing 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 microstructure and microchemistry 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. A new and unique facility for mechanical testing of miniature irradiated specimens was completed this year and installed in a shielded room within the reactor containment building. 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 active nuclear materials project has been an in-reactor irradiation experiment at the MITR-II. This experiment was 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 were subjected to stress and temperature cycles, ion bombardment, and fast neutron irradiation, all simultaneously. This work has been under the direction of Professor Harling. Three students, one a candidate for an S.M. and the other two Ph.D. and Sc.D. candidates, have been carrying out their thesis research on this project.

Other research activity included uranium assay using delayed neutron and track etch methods for a research project on the recovery of uranium from sea water by Professor Michael J. Driscoll's group, Department of Nuclear Engineering.

The MIT Reactor completed its 23rd year of operation, its seventh since the 1974-75 shutdown for upgrading and overhaul. During the past year it continued its usual Monday through Friday operating schedule at the design power level of 5 MW, averaging 84 hours per week at full power, holidays included. Energy output for the MITR-II, as the upgraded Reactor is now called, totaled 124,300 megawatt-hours at June 30, 1982. The MITR-I generated 250,445 MWH from 1958 to 1974.

The Reactor is increasingly utilized, although still more experiments and irradiations can be accommodated due to the number and versatility of its many facilities. Expansion continues in such areas as materials activation by the Trace Analysis Laboratory. For this and the other activities described above, the total irradiations during the year increased to 7,200, up from 5,973 during the previous year and 2,350 for the year before that. Consequently, the automated pneumatic "rabbit" system for transporting test specimens between the Reactor and the radiochemistry laboratories in Building NW13 saw increased usage, as did the hot cell inside the containment building and the radioactive material handling facilities in Building NW12.

The Nuclear Regulatory Commission resumed its inspections of the MIT Reactor after an almost complete hiatus for such activities in the aftermath of Three Mile Island. This lull, however, was more than offset by the sharp increase in emergency preparedness, radioactive material shipping, security, and other regulations. The US Department of Energy (DOE) renewed its "reactor sharing" grant whereby MIT is reimbursed for use of the Reactor by other education institutions needing such a facility for teaching or research purposes. DOE augmented the Reactor fuel supply without charge to the Institute and also undertook a development program designed to demonstrate the feasibility of extending the lifetime of uranium aluminide fuels used in some of the nation's high performance reactors such as the MITR-II.

Reactor irradiations and other research activities included: 1) continuing irradiation of sulfur targets for the production of 10 curies of P-32 per week for use in the labeling of proteins for use in biological research; 2) continuing research with the Department of State, Arms Control Disarmament Agency, in a communication program for the surveillance of reactors and reactor materials. This program is being expanded to add Dr. Marvin Miller and a student from the Department of Nuclear Engineering; 3) research activity under direction of Professor Ann M. Hirsch of Wellesley College and one student using nuclear track detection technique to study the uptake of boron in plants; 4) research activity by Professor Gene M. Simmons of the Department of Earth and Planetary Sciences and a research specialist using nuclear track detection techniques to study the distribution of uranium in granite. The program has been expanded and a student has been added to determine the uranium using delayed neutron detection techniques; 5) plans have been made, and lectures and experiment procedures written, to provide training for power reactor operators using the MITR-II to demonstrate reactor engineering and related science principles and techniques; 6) research support under the Federally funded Reactor Sharing Program includes 20 other educational institutions. Major research activities (not noted above) include: geochemical investigation by one professor and two students from Boston College; Mossbauer measurement using a ^{161}Tb source by one professor and a student from Clark University; and 7) research efforts aimed at demonstrating both the feasibility and the advantages of reactor control by digital control were continued under the direction of three staff members of the Charles Stark Draper Laboratory and Professor David D. Lanning, Department of Nuclear Engineering.

This program has demonstrated signal validations techniques. Studies regarding reactor control will commence shortly; these will provide experimental verification of several control techniques that have previously been studied only theoretically.

OTTO K. HARLING

Patent, Copyright and Licensing Office

Disclosures and Licensing

During the past fiscal year, 164 invention disclosures were received, 96 US patent applications filed, and 61 US patents issued. Additionally, 163 patent applications were filed in foreign countries corresponding to 16 US applications. Gross royalty income from patent and copyright licensing totaled $1,815,181. In addition, industry committed approximately $300,000 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 continued to concentrate in the general areas of medical/biological applications. Licensing and option agreements were executed with industrial concerns in these areas as well as in the technologies related to energy saving, metallurgical castings, and communications. This Office continues to work closely with the Office of Sponsored Programs in negotiating industrial research agreements.

In the absence of a separate patent marketing department, the Office has entered into an agreement with a European company to represent the licensing effort in Europe. To date, a number of valuable contacts with industrial firms have been made, and licensing discussions are in process. We also are working closely with Arthur D. Little, Inc., on a general review of our available licensing portfolio with the goal of increasing our marketing efforts. Additionally, we have begun discussions with other patent management firms in an effort to increase the efficiency and productivity of the marketing efforts. In this respect, the Office continues to interact closely with the Industrial Liaison Program and with the computer marketing services of Control Data Corporation, Dr. Dvorkovitz and Associates, and General Electric's Selected Business Ventures.

The Office has functioned for a year now under the new patent legislation, and we believe that this law has greatly facilitated the processing and licensing contact for government-sponsored inventions.

ARTHUR A. SMITH, JR.

Plasma Fusion Center

During the past year there has been significant technical progress in Plasma Fusion Center (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 level of the individual researcher 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 of MIT as an institution, is the ability to evolve new ideas and concepts in critical physics and technology areas required for development of fusion energy, and to train professional researchers. The PFC technical programs are supported by the Department of Energy's Office of Fusion Energy. During the past year, the funding level has been approximately $20.6 million. Approximately 270 technical personnel are associated with PFC research activities. These include more than 20 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), 130 research scientists and engineers, 75 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 understanding of the basic physics 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 device operations (Dr. David Gwinn), confinement studies (Dr. Stephen Wolfe), plasma-wall interactions (Dr. Earl Marmar), radio frequency heating (Professor Miklos Porkolab and Dr. Jack Schuss), and data acquisition and computations (Dr. Martin Greenwald). The experimental design activities during the past year emphasized advanced toroidal facilities with helical features as well as advanced tokamak designs in the high-field Alcator line (Drs. Peter Politzer and D. Bruce Montgomery). Professors Parker and Bruno Coppi are overall Alcator program principal investigators.

Alcator C

Study of the confinement properties of tokamak plasmas under conditions of intense ohmic heating power density continues to be the primary theme of the Alcator C toroidal research program. As discussed in last year's report, the measured confinement times have generally fallen below expectations predicted by the empirical scaling laws developed on Alcator A and other tokamaks during the late 1970s. This empirical scaling was based, in part, on the assumption that tokamak transport is dominated by a diffusive process which is independent of the major geometric scale of the device. This results in an energy confinement time τ_E which is proportional to the square of the minor radius R. The results reveal a surprisingly weak (less than first power) dependence of τ_E on minor radius, contrary to the empirical expectation, and a relatively strong dependence on R (with a power greater than or equal to two). This implies that the transport coefficient depends on geometry as well as plasma parameters.

Although the best confinement time for fixed density and minor radius occurs at the largest value of the major radius, operation at the smallest value of major radius (R = 58 cm) has produced the best value of the density-confinement-time product $n\tau_E$. This is because the maximum plasma density is proportional to B_T/R (B_T is the toroidal field), and this parameter increases proportional to R^{-2} for fixed magnet current. The best parameters obtained with a = 10 cm and R = 58 cm are: average density $\bar{n} = 8 \times 10^{14}cm^{-3}$, central density $n_0 \sim 1.2 \times 10^{15}cm^{-3}$, energy confinement time τ_E = 30 msec, and corresponding $n_0\tau_E \times 10^{14}sec\text{-}cm^{-3}$. These results were obtained at B_T = 12.4T. Some operation with fields slightly in excess of 13T has also been explored.

RF-Heating

The second phase of the Alcator C experimental program -- the use of high power radio frequency (RF) waves to raise the plasma temperature and to test recent ideas on RF current drive -- has begun with the installation of a four-waveguide array antenna. With this array, a maximum power of 160 kW was coupled into the plasma at 4.6 GHz, which corresponds to $8kW/cm^2$ transmitted power per unit area, a record value. The observed coupling efficiency was excellent (typically 90 percent). The heating observed was modest due to the low total RF power (which represented only 10 to 15 percent of ohmic heating power). In addition, initial results on RF current drive were observed at the 50 kW level, with an efficiency of 1 kA/kW at a density of $\bar{n} = 3 \times 10^{13}cm^{-3}$ (which is a higher density than that observed in other tokamak experiments). More recently, the coupler was replaced with the first 16-waveguide array developed successfully in a joint program with Varian Associates. This represents a major advance in the technology of waveguide/vacuum window technology, and it insures that several MWs of microwave power can be delivered through the four larger ports of

Alcator C. The experiments using this coupler have just begun, and the goal will be to inject 500-700 kW of RF power through such a coupler. Meanwhile, a 600 kW ICRF (ion cyclotron resonance heating) experiment operating at 180 MHz is being prepared for installation in Alcator C in 1983. This system combines one of the lower-hybrid power supply/modulator units and the FPS-17 radar system donated to the Plasma Fusion Center by the US Air Force.

Advanced Toroidal Development

A study program continued to explore conceptual advances in the area of toroidal fusion systems and to consider potential new PFC experiments in this area. The preconceptual designs include advanced helical systems (such as the helical axis or "snake" stellarator), more conservative torsatron configurations, and advanced tokamak configurations such as RF-driven or RF-assisted tokamaks. The various options are being compared using criteria such as improvements to toroidal confinement under conditions of high beta (the ratio of plasma to magnetic pressure) and desirability as a reactor concept (for example, the potential for continuous operation and simplicity of design). A concept choice is expected to be made during the coming year. A two- to three-year construction phase is foreseen, after which the selected device would replace Alcator C as the major experimental facility in the PFC toroidal confinement program.

MIRROR CONFINEMENT EXPERIMENTS

In the fall of 1980, the Mirror Confinement Systems Division, headed by Dr. Richard S. Post, prepared a technical proposal to the Department of Energy (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 Lawrence Livermore National Laboratory (LLNL), and the project was approved by the DOE in the fall of 1981. The construction costs for the TARA device are approximately $13 million over a 30-month period, with initial operation scheduled for November 1983. The principal investigators are Drs. Post and Jay Kesner, and the TARA device will be sited in the west wing of the Nabisco Laboratory. The TARA experiment will significantly complement the mirror research activities at LLNL as well as the ongoing PFC research activities in mirror theory and the Constance II experimental program.

The TARA tandem mirror configuration is unique and utilizes an axisymmetric confining plug with an "outboard" minimum-B anchor. It has been identified as the most desirable tandem mirror configuration for potential reactor applications. The primary objectives of the experiment will be to test plug micro-stability, overall MHD stability and beta limits, central cell radial transport, and thermal barrier formation. The experiment will provide data for the proposed upgrade of the MFTF-B facility under construction at LLNL.

The following is a brief summary of the TARA design. The TARA central cell is a 15 cm radius, 5 m long solenoid. When a thermal barrier is present, the projected plasma parameters are $T_e \sim T_i \sim 400$ eV and $n_e = 4 \times 10^{12} cm^{-3}$. Ions are confined by axisymmetric plugs which eliminate the possibility of enhanced radial transport that is driven by the quadrupole moments of the plugs (so-called "resonant" transport).

The central solenoid is bounded by high mirror plugs (R = 5-6) with peak and midplane fields of 3 and 0.5T, respectively, Neutral beams (20 keV extractor energy) with 150 A current are injected at a 40° angle into the plugs to create a sloshing-ion distribution which is expected to exhibit improved microstability properties and provide a partial thermal barrier. Gyrotrons at 28 GHz will be available with a capability of 200 kW per plug for creating the hot mirror-trapped thermal barrier electron species and the suprathermal ($T_e \sim 700$ eV) warm electron species. Thus, a thermal barrier is expected to form at the midplane of the plugs.

A unique feature of the TARA configuration, and one that provides a substantial reduction in cost and technology requirements, is the use of RF-driven MHD anchors. The anchor will be formed in externally located baseball coils that were formerly the plugs in TMX. They will operate steady-state and contain a low-density ($n_e \sim 5 \times 10^{11} cm^{-3}$) hot-electron plasma, formed by electron cyclotron resonance heating (ECRH) in the X-band. Additional ion heating utilizing ion cyclotron range of frequencies (ICRF) will be used to augment beta values in the anchor.

During the past year the major components of the machine design were completed, and procurement for the RF, vacuum, magnet, magnet power supply, and data systems has been initiated. Support laboratories were assembled for diagnostics, neutral beam prototype, RF systems, and vacuum prototype development. In August 1981, the architectural firm of Symmes, Maini & McKee was contracted to undertake the design of the TARA site preparation in the west wing of the Nabisco Laboratory. The decision to locate the experimental cell adjacent to the Nabisco Laboratory and develop the cell roof for power supply space resulted in a site design yielding 31,400 square feet of useful experimental space. The design process culminated in a request for bids in May 1982. The construction firm of Bond Brothers, Inc., was the successful bidder, and its bid is currently under review by the DOE. It is anticipated that site preparation will begin in July 1982, with completion scheduled for February 1983.

APPLIED PHYSICS RESEARCH

The primary objective of the PFC's Applied Physics Research Division, with Professor Ronald Davidson as acting head, is to develop the basic experimental and theoretical understanding of plasma heating and confinement properties. Present applied physics research activities include experimental research on the Versator II tokamak (Professors George Bekefi, Porkolab, and Dr. Stanley Luckhardt); experimental research on the Constance II mirror device (Professor Louis Smullin); fusion theory and computations (Professors Abraham Bers, Coppi, Ronald Davidson, Thomas Dupree, Jeffrey Freidberg, James McCune, Kim Molvig and Dr. Kesner); development of the MACSYMA symbolic manipulation system (Professor Joel Moses); plasma diagnostics and laser development (Drs. Daniel Cohn and Paul Woskoboinikow); development of advanced stellarator/torsatron concepts (Professors Lawrence Lidsky and Freidberg); and 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-size research tokamak (major radius = 40.5 cm; minor radius = 13 cm; toroidal magnetic field = 15kG) with primary emphasis on basic investigations of plasma heating and confinement properties. Lower-hybrid current-drive experiments on Versator II have drawn significant national and international 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 15kA 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 30kA). 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 ($n_0 \lesssim 10^{13}cm^{-3}$, whereas a reactor would operate at densities in excess of $10^{14}cm^{-3}$. Ways to increase the density limit are presently under investigation, as well as the detailed physical mechanism responsible for RF current drive. One possible way to increase the density limit is to inject ECRH power in order to establish a high energy electron tail before (or during) lower-hybrid power injection. This experiment was carried out on Versator II, with the result that while the density limit was not raised, the overall current-drive efficiency was improved. The improvement was attributed to stabilization of an instability (driven by the highly anisotropic distribution function) which tends to limit the current drive efficiency. During the coming year, a 100kW S-band (2.45GHz) system will be installed in an attempt to overcome the density limit. Future plans also 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.

Finally, studies of ECRH have been completed in collaboration with scientists from the Naval Research Laboratory (NRL). Microwave power at a frequency of 35GHz and 100kW was 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.

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-cathod plasma gun that generates hotter and denser plasma than the washer guns used previously. The guide field strength has been increased from 1.8kG to 2.8kG 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 in 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 electric 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. During the past year, ECRH experiments have been completed on Constance II, including an investigation of heating rates at various antenna launching angles and over a variety of plasma conditions. Also, a modulated electron beam experiment has been initiated to investigate coupling of the beam power to the plasma electrons.

To better coordinate the mirror research activities on Constance II and TARA, the Constance II experiment will be moved to the new mirror wing of the Nabisco Laboratory. As a part of this move, a baseball magnetic field coil obtained from LLNL will replace the present axisymmetric coil/Ioffee bar coil set currently employed. Future work will involve the production of hot electron plasmas in which ions will be pumped from the plasma by bounce resonance ion heating. The objective is to make negative-potential plasmas to study their production and microstability properties.

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) development of a self-consistent plasma model which simultaneously includes the effect of neoclassical transport and plasma turbulence; b) continued development of self-consistent theoretical models describing anomalous 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) development of a self-consistent kinetic description of the free electron laser instability including the important influence of novel magnetic field configurations and 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-He^3).

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 and ARPA network. The continuing 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. Much progress has been made this year on the project 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. A version of NIL is being tested on the PFC's VAX. The efficiency of MACSYMA in NIL is continuing to be improved.

In the area of advanced fusion concepts, there has been a continued emphasis on the development of stellarator/torsatron 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 and MHD stability properties.

In the area of plasma diagnostics and laser development, substantial progress has been made in the development of a system for collective Thomson scattering measurements of ion temperature. A system capability to measure a Thomson scattered signal which is 20 times above thermal level has been achieved. A key element in the attainment of this level of sensitivity is the use of a gas absorption cell for stray light rejection. Through the use of a high-power laser and strong stray light filtering, the system has the capability to make scattering measurements which are 10^6 times more sensitive than previous measurements which were made with low-power far-infrared systems. The system has been employed to detect strong nonthermal-level scattering from fluctuations which accompany disruptions.

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 TARA tandem mirror experiment and for proposed follow-on experiments in the Alcator/toroidal confinement area; design support for the magnetic systems of the national Fusion Engineering Device and for the INTOR international tokamak reactor (Joel Schultz and Dr. Richard Thome); responsibility to develop improved magnetic divertor concepts (Dr. Ted Yang); the development of forced-flow superconductors for application to advanced fusion devices (Mitchell Hoenig); 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:

A proposed next major step in the US fusion program is a 200 MW output, 100-second-burn engineering device known as the Fusion Engineering Device (FED). A six-member technical management board, of which Dr. Montgomery is a member, was 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. A major documented study was carried out during 1981. Work is continuing in examining a broad range of alternate approach devices suitable for a prototypical fusion reactor which would be built in the early 1990s.

The PFC Fusion Technology and Engineering Division has carried responsibility for the Magnetics Branch of the FED Design Center activities during 1980-81. This work has been carried out in close cooperation with the FED Design Center Headquarters at Oak Ridge National Laboratory (ORNL), which has overall responsibility for systems integration. Since the beginning of 1982, General Electric has assumed responsibility for the magnetics branch activities, and the PFC has taken responsibility for critical issues of both the FED device and the INTOR international tokamak design project.

The PFC has been active in developing improved magnetic divertor concepts. 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 PFC completed the major construction of a high-field divertor for the ISX-B tokamak at ORNL in 1981. Professors Borivoje Mikić and Neil Todreas and their students have been active during the past 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 × 3 meter niobium-tin coil for the Large Coil Project at ORNL and for the FED baseline reference design. 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 LLNL.

Basic research on advanced superconducting materials is also a major fusion engineering activity in the PFC 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 possibly significant reduction in production costs over conventional industrial preparations.

FUSION SYSTEMS

The Fusion Systems Division, headed by Dr. Cohn, investigates several aspects of fusion reactor design and develops advanced millimeter and submillimeter wave technology for plasma heating and diagnostics. Research activities include safety and environmental studies (Professor Mujid Kazimi);

reactor system studies (Dr. Cohn, Professor Lidsky, and Dr. John Williams); blanket and first wall structural design studies (Professor John Myer); 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, a methodology has been developed for radiological hazard assessment which provides a means to more clearly delineate the safety impact of using different reactor materials. In addition, an assessment of environmental impact of waste management schemes, and an experimental program to determine the effect of plasma disruptions on the first wall containment vessel, have been initiated during the past year. Finally, a code to model lithium fires has been developed and made available to the national fusion community through the National Magnetic Fusion Energy Computer Center at LLNL.

The reactor systems studies group has investigated a number of important concepts during the past year. Three design studies of particular significance include: a compact, high-field tokamak reactor for engineering studies; an advanced fuel tokamak power reactor operating on a tritium-lean deuterium-tritium fuel mixture; and a continuous winding torsatron power reactor. The compact tokamak FED utilizes high-performance resistive magnets and has a substantially reduced size and cost relative to the mainline FED design which uses superconducting magnets. The advanced fuel tokamak power reactor has an attractive solid breeder blanket design which is made possible by the reduced requirement for tritium breeding. The design of this reactor, which utilizes high-field superconducting magnets, illustrates how the high values of $n\tau_E$ and the high fusion power density achievable in a tokamak could be used to increase safety, environmental, and engineering features of tritium breeding blankets. The continuous winding torsatron reactor concept is attractive because of its capability for steady-state operation and reduced magnet stresses relative to other stellarator/torsatron configurations. Maintenance is an important issue in this type of device, and a design concept has been developed for the removal of blanket segments between the superconducting coils.

The gyrotron and advanced millimeter source group has obtained a power level of 100 kW from a high frequency (140 GHz) gyrotron (electron cyclotron maser) device developed at the PFC. Measurements of the basic operating characteristics of the device were obtained and found to be in agreement with theoretical predictions. The achievement of a 100 kW power level from the device is a very notable accomplishment, representing a world record for high-frequency gyrotron operation. More detailed studies of device performance are in progress, and gyrotron concepts for production of higher power levels are under investigation.

In the area of submillimeter wave technology development, a gas absorption cell for stray light reduction in submillimeter laser scattering experiments has been constructed and found to be very effective in tests on the Alcator C tokamak. Schottky barrier diode frequency doublers, for use as tunable local oscillators for heterodyne measurements of cyclotron emission and scattered radiation, also are being developed. Schottky barrier diode detectors are being provided to other fusion laboratories.

APPOINTMENTS AND PROMOTIONS

During the past year, there have been several important appointments and promotions in the PFC program areas.

Appointments include: James Alexander (MIT), appointed to the engineering staff in the TARA diagnostic program; Craig Bredin (Honeywell Avionics), appointed electrical design engineer in the Alcator program; Daniel Bruscella (EMS Development Corporation), appointed power electronics engineer in the TARA confinement program; Dr. Rex Gandy (University of Texas), appointed experimental research scientist in the Alcator program; Dr. Marcel Gaudreau (MIT), appointed research engineer in the TARA power electronics and systems integration program; Dr. Robert Granetz (MIT), appointed experimental research scientist in the Alcator program; Dr. Dennis Hewett (Los Alamos National Laboratory), appointed research scientist and associate group leader in the fusion theory and computations program; Dr. Kyriakos Hizanidis (MIT), appointed

postdoctoral associate in the fusion theory and computations program; Dr. Barton Lane (MIT), appointed postdoctoral associate in the tandem mirror theory program; Walter Mann (Magnetic Corporation), appointed magnet design engineer in the technology and engineering program; Dr. Michael Mauel, (MIT), appointed experimental research scientist in the TARA confinement program; Dr. Steven McCool (University of Texas), appointed experimental research scientist in the Alcator program; Michael Olmstead (MIT), appointed research engineer in the TARA design program; Edward Shaw (MIT), appointed systems programmer and analyst in the Alcator confinement program; Robert Thayer (MIT), appointed systems programmer and analyst in the Alcator confinement program; Jacques Thompson (MIT), appointed to the research administrative staff in the TARA confinement program; Dr. Richard Torti (University of Wisconsin), appointed experimental research scientist in the TARA neutral beam program; and Fee Yee (MIT), appointed to the engineering staff in the TARA diagnostics program.

The magnetohydrodynamic (MHD) and magnet design programs headed by Dr. Montgomery became a part of the PFC's Fusion Technology and Engineering Division in the spring of 1982. This has resulted in the following transfers of sponsored research staff to the PFC: Herbert Becker, structural analysis engineer; Alberta Dawson, research administrative staff and technical writer; Albert Hatch, magnet design and analysis engineer; William Langton, computational engineer; Peter Marston, MHD program manager; Dr. Montgomery, senior research engineer, associate PFC director and head of the Fusion Technology and Engineering Division; Robert Pillsbury, electro-magnetics computational engineer; Daniel Sliski, design engineer; John Tarrh, associate group leader for contract management; and Dr. Thome, magnet design engineer and associate group leader.

During the past year, Institute research promotions in the PFC include: Dr. James Irby, promoted to experimental research scientist in the TARA confinement program; Dr. Robert Potok, promoted to research scientist in the reactor studies program; Frank Tambini, promoted to the engineering staff of the Alcator confinement program; and Dr. Temkin, promoted to principal research scientist in the gyrotron development program.

Internal PFC promotions to group leader positions of major programmatic responsibility are: Dr. Greenwald, leader, Data Acquisition and Computations Group in the Toroidal Confinement Experiments Division: Dr. Gwinn, leader, Operations Group in the Toroidal Confinement Experiments Division; Dr. Kesner, leader, Computations and Advanced Concepts Group in the Mirror Confinement Experiments Division; and Donald Nelson, computer systems manager in the Toroidal Confinement Experiments Division.

During the past year, the PFC has had several visiting scientists in the various research programs. They are: Professor Gerhard Berge (University of Bergen), stellarator stability properties; Professor John Davies (Clark University), theory of free electron lasers; Professor Ward Getty (University of Michigan), experimental mirror plasma physics; Dr. Elisabeth Kallne (Smithsonian Astrophysical Observatory), soft X-ray emission studies on Alcator C; Dr. Young Ping Pao (Courant Institute), stellarator stability properties; Professor Philip Rosenau (Israel Institute of Technology), magnetohydrodynamic theory; Dr. Dieter Sigmar (ORNL), stability and confinement of thermonuclear plasmas; and Dr. Vladislav Stefan (Boris Kidric Institute for Nuclear Sciences, Yugoslavia), nonlinear wave propagation in plasmas and plasma heating.

RONALD C. DAVIDSON

Research Laboratory of Electronics

The Research Laboratory of Electronics (RLE) is an on-campus research environment which provides faculty members and their students with the diverse services and facilities of a large laboratory. RLE was established at the end of World War II as the Institute's first interdepartmental laboratory. It 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, postdoctoral staff, and students. Approximately 75 members of the faculty are affiliated with the Laboratory and work with about 250 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 20 doctoral, two engineer's, 12 master's, and 20 bachelor's theses.

Major support for the research is provided by the Joint Services Electronics Program of the Army, Navy, and Air Force, as well as other agencies of the Department of Defense, the Department of Energy (DOE), the National Science Foundation, the National Institute of Health, and the National Aeronautics and Space Administration.

General Physics

The general physics area contains such subjects as solid state and 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.

Professor Shaoul Ezekiel and his students devoted their research studies to the interaction of two laser fields with a three-level system in an atomic beam. Of particular interest was the basic study of coherent two-photon excitations for various configurations of the three levels in the system. They investigated both weak and intense field excitations and fit the data to theoretical predictions. The data in vapors showed strong evidence of nonlinear optical effects, such as self-focusing, even in very low pressures.

Professor John D. Joannopoulos' group continued theoretical studies of semiconductor surfaces and defects. During the past year, they developed a new theoretical technique for calculating elementary excitations on surfaces that is simple, tractable, and an order of magnitude faster than currently available schemes.

The measurements of photoluminescence (PL) in amorphous SiO_2 by Professor Marc Kastner's group have demonstrated that there are several separate PL spectral bands associated with atomic-scale defects. They can identify the different bands not only by their photon energy but also by their rate of decay after excitation and by the temperature dependence of the decay. This suggests that one may be able to identify the signature of a specific defect through the properties of its PL. Since some defects are known to have deleterious effects on the electronic properties of electronic devices and optical fibers, such signatures would be very useful in quality control. It is believed that defects play a central role in determining the electronic properties of a wide variety of amorphous materials. Understanding the structure and properties of such defects is therefore very important in solving the more general problem of the physics of amorphous solids.

Activity in the area of optics and quantum electronics continued to expand. Professors Hermann A. Haus and Erich P. Ippen and their students have been developing novel waveguide optic devices for ultra-high-speed signal processing and new lasers for studies of material processes on a sub-picosecond timescale. Advances during the past year include the first demonstration of an all-optical, picosecond waveguide, logic element and the extension of picosecond laser capabilities to new wavelengths and improved temporal resolution.

Professor Michael Salour and his students continued research on the development of tunable CW radiation of a bulk semiconductor platelet laser in external cavities in both mode-locked and non mode-locked configurations. The platelets were composed of CdS, CdSe, and InGaAsP. These compact lasers have demonstrated the potential for low noise and broad tunability.

In another series of experiments, Professor Salour's group has determined photographically the recombination time of electron and hole pairs in semiconductors. A semiconductor was excited by a picosecond optical pulse. The formation of the electron-hole pair and their decay was directly photographed and measured by an extremely sensitive and ultra-high-speed electron-optical camera. This camera was built by Professor Salour's group here at MIT in another experiment. The coupling of photons to excitons was used to compensate for the group velocity disperson in optical fibers. This has important applications for distortion-free optical pulse propagation through fibers.

Professor Jin Au Kong and his students 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 were carried out with rigorous analytical approaches. Solutions for scattering by periodic rough surfaces were applied to optical as well as microwave frequencies. The theoretical work on microwave remote sensing of earth terrain has gained international attention; 12 journal articles and eight conference papers were published in the past year.

Professor Frederic Morgenthaler continues research on localized magnetostatic modes. Microwave magnetics technology is being called upon to provide analog signal processing capabilities directly at microwave frequencies and also to create electronically tunable nanosecond time delays for phased-array antennas. Although magnetostatic wave devices normally employ spatially uniform magnetic bias, control of important features of the modes is afforded through judicious use of dc field gradients. Such control can be the basis for new forms of microwave signal processors. Professor Morgenthaler has pioneered the use of such gradients to control the frequency dispersion or other prespecified device characteristics. The goal of this research is to achieve a synthesis procedure that will allow device characteristics to be realized to exacting standards.

Professor J. David Litster and his students are using time-resolved spectroscopy in conjunction with light scattering and X-ray scattering to study the properties of condensed phases of matter. Their goal is to understand why large numbers of interacting particles form the phases which they do and why they have the properties they have. Phase transition is one of the most important problems of current interest in physics.

Professor Robert J. Birgeneau and his collaborators continued their studies of phase diagrams, structures, and structural phase transitions of several model systems, including molecular oxygen, and krypton and xenon physisorbed onto the basal planes of ZYX exfoliated graphite. They anticipated that synchrotron sources would prove invaluable in elucidating such surface structures and transitions. Accordingly, high resolution synchrotron X-ray diffraction studies were initiated that yielded a number of important surprises. The demonstration of the usefulness of synchrotron sources for such studies has had a large impact on the community as a whole.

The Submicron Structures Laboratory, under the direction of Professor Henry I. Smith and Principal Research Scientist John Melngailis, has completed three years of operation. The most noteworthy progress during the past year was in three projects: 1) single crystal thin films of silicon have been produced on insulating substrates by zone melting through planar constrictions; 2) gratings of 0.1 μm period have been produced starting from 0.2 μm period using deep UV lithography and the technique of spatial period division; and 3) MOS structures have been fabricated on silicon in which the gate region is a narrow channel approximately 50 nm wide. The conductivity along this channel shows sharp oscillations at liquid helium temperatures as the gate voltage is varied. The source of the oscillations is not yet theoretically modeled, but the oscillations are believed to be one of the first observed effects of confinement of electrons to "one-dimensional" conduction. Examples of other achievements in the laboratory are: reactive ion etching of aluminum with a mixture of SiF_4 and O_2; fabrication of an X-ray lithography mask for a superconducting Josephson microbridge interferometer; and a surface acoustic wave grating device which acts as a filter due to the conversion of surface acoustic waves to bulk plate modes.

Professor Daniel Kleppner and his group obtained new results in a study of spontaneous radiation from excited atoms. Spontaneous emission is often regarded as being stimulated by zero-point fluctuations in the radiation field. It was discovered that these fluctuations can be reduced and the spontaneous radiation inhibited by placing the atoms in a suitably mistuned cavity. Spontaneous emission is the most elementary irreversible process in nature and is the fundamental source of noise in quantum electronic devices. The ability to control this radiation has important practical implications. It should also be possible to enhance the zero-point fluctuations in a cavity; experiments to demonstrate this are in progress. This research provides new opportunities to study novel phenomena in quantum electrodynamics, quantum optics, and coherence theory.

The most probable inelastic collision between a molecule and an atom is rotationally inelastic but vibrationally elastic: only the rotational quantum number of the molecule changes, from j_i to j_f. For years these collisions have been referred to as energy transfer collisions, yet in the last year new experimental and theoretical results from Professor David Pritchard's group have shown that angular momentum transfer is the more important physical variable. In this dynamical view, cross

sections for excitation of an initially non-spinning molecule are calculated from the long-range atom-molecule interaction using a simple classical theory which has demonstrated ∿30 percent accuracy. These cross sections are then combined according to the energy-corrected sudden scaling law to yield the cross sections from j_i to j_f. If the three parameters of these combined theories are regarded as variable, then the resulting laws may be regarded as fitting laws. It has been possible to fit, with only 10 percent average error, large experimental databases in which the cross sections, j_i and j_f, varied over roughly two orders of magnitude. Recently these expressions, which contain explicit dependence on the relative velocity, have been shown to fit the measured velocity dependence of the cross sections. The success of these theories in explaining the velocity-dependent cross sections is strong evidence of their ultimate validity and utility.

Dr. Philip W. Rosenkranz, Professor David H. Staelin, and graduate student Michael Komichak have developed a new nonlinear method for estimating atmospheric water vapor profiles using passive microwave data near the 60-GHz oxygen band and the nearly opaque 183-GHz water vapor band. The anticipated performance of such a dual-band mapping spectrometer over land and sea makes it a good candidate for inclusion on future operational weather satellites. Professor Staelin and Dr. Rosenkranz also have shown that certain short radio bursts originating in the Jovian magnetosphere near the local electron cyclotron frequency can be explained if they arise from cusps in electron density formed when ∿2.5 KeV longitudinal electron streams are longitudinally modulated with hundreds of volts at several Hertz. Such cusps produce a very characteristic cyclotron emission signature that appears as a vee in the frequency-time domain due to the tendency for such electron density cusps to bifurcate immediately after their formation. Studies of such vee-bursts suggest values for several key physical parameters in the radio burst emission region; these should facilitate the ultimate explanation for this phenomenon.

Professor Alan H. Barrett and his students studied the molecular cloud believed to be associated with the center of our galaxy. Radio astronomical facilities in Massachusetts, Arizona, and New Mexico have been utilized to observe the spectral lines of ammonia, carbon monoxide, and isocyanic acid covering a wavelenth range from 0.3 - 1.3 cm. The observations reveal that the total gas density in the cloud may be a factor of 10 higher than supposed, implying a total mass of the cloud correspondingly larger. Observations with the Very Large Array provide an angular resolution of the order of one second of arc and show that the cloud is actually composed of as many as 10 individual condensations, which are regions of higher temperature or density than the surrounding cloud material.

Professor Sylvia Ceyer's group began to design and build an apparatus to investigate the effect of the incident energy of neutral species on the probability of dissociative adsorption on semiconductor surfaces. Studies of the effect of the energy of the incident molecule on the dissociation probability are nonexistent because most surface studies are undertaken after adsorption of ambient molecules. The apparatus being designed employs molecular beam techniques to define and control the energy of the incident molecule. The presence and amount of dissociation are detected sensitively by high-resolution electron-energy-loss spectroscopy utilizing vibrational spectroscopy. These fundamental studies on the effect of a molecule's incident energy on dissociative adsorption are important because of the unknown chemistry which these "hot" neutral molecules carry out during the plasma etching of semiconductors, where translationally and internally excited molecules are produced by numerous collisions with fast ions and electrons. The long-range goal of this research is to provide far-reaching correlations between the observed dynamics and the potential energy surfaces on which molecule-surface reactions occur.

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.

Professor Abraham Bers and his research group continued their studies of plasma heating for achieving energy generation by nuclear fusion. Plasmas can be heated with the electromagnetic power converted to random kinetic energy of the plasma particles. Such heating is known generically as "RF heating." The studies included analyses of RF-driven steady-state currents for confining

a toroidal plasma -- a problem of importance for achieving a continuously operational, tokamak-type reactor which has been addressed previously. In the past year, a study was completed which proposes a novel way of using RF heating to achieve a stable, subignited fusion reactor operation with appreciable output power. This work was carried out by graduate student L. Harten in collaboration with Dr. V. Fuchs of the Hydro-Quebec laboratory IREQ in Canada.

Professor George Bekefi's research focuses on experimental and theoretical studies of generating intense, coherent electromagnetic radiation in the microwave and submillimeter wavelength range, by energy conversion of relativistic electron beams. Three major types of systems are under investigation: relativistic magnetrons, gyrotrons, and free electron lasers. Three pulsed, high-voltage accelerators capable of delivering up to 50 KA of current at 0.5 to 1.5 MV are used in the experiments. Professors Bekefi and Miklos Porkolab also continue their work on Versator II.

Professor Louis D. Smullin, Dr. Robert J. Klinkowstein, Dr. James H. Irby, and graduate students continue their studies of instabilities in mirror-confined plasmas. These experiments focus on the problem of micro-instabilities.

Professor Bruno Coppi's research program focused on the combined experimental and theoretical investigation of plasmas in which fusion reactions have a significant influence on their thermal energy balance. Their characteristic line of interest centers on particular plasmas with relatively high densities. The experimental devices they have developed are represented by the prototype Alcator A machine, which is characterized by toroidal plasma columns that can sustain both high currents and current densities. This requirement, leading to adoption of toroidal magnet configurations of compact size and relatively high fields, has made it possible to achieve and maintain record values for the combined confinement parameters "$n_T\tau$," the product of the peak particle pressure n_T and the energy replacement time τ. In addition, a sequence of plasma regimes of basic physical interest, in terms of the different characteristics of the electron distribution in velocity space and of the collective modes that are excited, has been produced. Plasma regimes of thermonuclear interest that are nearly impurity-free have been realized at the same time.

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 human communication.

Professors Jeffrey H. Shapiro, Robert S. Kennedy, Robert H. Rediker, and their students worked to advance the understanding of a variety of optical and quasi-optical communication and radar systems. During the past year, work on atmospheric optical communications was redirected toward assessing the use of these links as branch or bridge elements in local computer networks. In another program, laser radar experiments performed in cooperation with Lincoln Laboratory verified some of the earlier theoretical predictions of atmospheric effects on system performance. Propagation and communication analysis of millimeter-wave communication through rain has shown there may be promise to adaptive diversity reception for such links. Work also proceeded on the experiment, undertaken with Professor Salour, to generate a light beam with reduced quantum noise; an experimental facility to measure the photon statistics of nanosecond duration optical pulses was assembled and tested. Finally, successful experiments were performed on an external cavity semiconductor-diode laser which has an optical fiber within the cavity. These experiments are forerunners of a system which will coherently couple a large number of low-power semiconductor lasers through fibers to produce a high average power semiconductor laser for space communications.

Professors Alan V. Oppenheim, Arthur B. Baggeroer, James H. McClellan, Jae S. Lim, and graduate students have developed a number of new signal processing techniques and are applying them to speech, bloodflow, and image and geophysical data processing. The speech processing work is directed towards 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, a new image restoration system has been developed for improving degraded images, and a new set of conditions has been derived under which an image can be restored from its Fourier transform phase or magnitude

alone. The geophysical data processing work has involved the development of an algorithm to measure the acoustic reflection coefficient from the ocean bottom. This algorithm, utilizing the Hankel transform, has potential applications to a number of other problems.

Professors William F. Schreiber, Donald E. Troxel, and their students are continuing research on computer-assisted image processing systems for graphic arts applications. A complete pre-press system for monochrome printing has been designed and installed at a large gravure plant, where it is used in daily production. It incorporates a page composition system and features engraving of printing cylinders directly from computer data. Initial tests are being carried out on a color system. 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 enhancing quality.

Professor Jonathan Allen and his students continue their work on custom integrated circuit design. The design problem consists of establishing an initial architecture, then designing each module of the resultant architecture. They have obtained the designs for the cells either from a library of previous designs, from a program that can generate a given type of cell, or from interactive use of a layout language. Their research has led to the development of layout programs that provide for the representation of cell types in terms of variables of the design that can be bound by the user. They also have developed both logic and layout optimization techniques for use with these programs. A high-performance signal processing chip is being designed using these techniques.

Research by Professor Louis D. Braida and his colleagues (Research Scientist Nathaniel Durlach, Principal Scientist H. Steven Colburn, and Research Associates William Rabinowitz and Charlotte Reed) is concerned with the development of a unified quantitative theory of intensity perception and loudness, and involves the construction and integration of models of sensory processes, short-term memory, perceptual context effects, and decision making, as well as intensive psychophysical experimentation. Their work on auditory perception has focused on intensity perception, pitch perception, spectral shape perception, 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 hearing aids has focused on the development of improved signal-processing schemes 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 produced the following studies. Together with Professor Robert M. Rose of the Department of Materials Science and Engineering, the group demonstrated that caisson disease, caused by 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, 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 tectun, those of the optic nerve and those of the nucleus isthmi. These are separate moieties. In collaboration with Dr. Eric A. Newman and Dr. Peter Hartline of the Eye Research Institute, he examined the infrared receptors of a rattlesnake and the cells responding to them in the brain. The anatomical results as well as the physiology are now being prepared for publication. Dr. Steven Raymond applied his method of determining 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 extended a portion of his theory of membrane control to a new model for ion adsorption kinetics to the membrane surface.

The objective of research by the Linguistics faculty is to gain a better understanding of human mental capacities by studying the ways in which these manifest themselves in language. Scientific descriptions of language have for a very long time followed a standard format. A number of topics are almost invariably discussed: pronunciation, the inflection of words, word formation, the expression of syntactic relations, word order, and so forth. Moreover, the manner in which these have been treated also has been quite standard. While traditional grammars have many shortcomings, their great practical utility is beyond question; generations of students have acquired adequate command of innumerable languages with the help of grammars of the standard

type. A plausible inference that might bedrawn from this is that languages are somehow not very different from one another and the traditional standard format has succeeded in capturing essential aspects of what all languages share in common. Accordingly, much of the research of this group has been devoted to studying the common framework that underlies different languages and the general principles that are exemplified in the grammar of different languages. Results strongly indicate that this assumption is indeed correct as far as the linguistic evidence is concerned.

JONATHAN ALLEN

Vice President, Resource Development

This past year, the second since the close of the Leadership Campaign, was filled with new challenges, problems, and opportunities. One of the most urgent needs of a post-campaign period is to find the "new money" that will replace the payments on campaign pledges. At the end of fiscal year 1981, the first year after the campaign, about 75 percent of the gift cash flow was not related to campaign commitments; at the end of fiscal year 1982, that fraction had risen to almost 90 percent. Although we are very encouraged by this achievement, continuing fiscal pressures make it clear that we must do more.

The decline in Federal funds for research and development has created increasing competition for support from foundations, corporations, and individuals. This competition for funds exists not only among various universities, but also among MIT's own schools, departments, and faculty members. Thus, Resource Development faces increasing pressure to identify new prospects among the private funding constituencies, to assist deans and faculty members in determining the funding sources most appropriate to particular teaching or research groups, and to set up working groups to acquire funds for these goals. The basis of this process is the identification and evaluation of specific academic priorities by department heads, deans, and senior officers. Also of importance has been the development of our departmental plans for the immediate future: how to carry out our mission most effectively, especially in light of budget reductions which are affecting all of us throughout the Institute.

Considerable progress was made during the year toward funding two major Institute programs. The microsystems research and education program, Very Large Scale Integration (VLSI), has received $5 million in cash commitments, and capital cost recovery from government overhead charges has been estimated at $9.9 million. The program has an estimated capital cost of $21.1 million. Funding for the Arts and Media Technology Facility, with a projected cost of $25 million, stood at $19.2 million as of June 30, 1982.

Of special concern is support for students and faculty members. An outstanding faculty and outstanding students are mutually dependent: the presence of each attracts the other. During the year, seven endowed chairs were established for the support of senior faculty members, as well as two career development chairs for junior faculty. Funds for student aid, both graduate and undergraduate, remain a central goal and will receive increased attention in the forthcoming year.

The past year witnessed continued improvement in communications and interaction among the several groups within Resource Development, creating a more efficient operating unit. In addition, better interaction with the Alumni Association, particularly in the area of class reunion gifts and planned giving, resulted in more effective operations and a more unified approach to alumni.

Private Support

Total private support of MIT during the past year was $46.6 million, somewhat less than the previous year's record high. The total comprised $41.1 million in gifts, grants, and bequests, and $5.5 million in support through membership in corporate liaison programs (discussed elsewhere in this report). The total compares with $46.7 million in 1981, $38.1 million in 1980, $37.4 million in 1979, and $34.4 million in 1978. The Leadership Campaign had only a residual effect on cash flow in 1982.

Sources of gifts for fiscal year 1982 were: alumni, $9.1 million; non-alumni friends, $3.4 million; corporations, corporate foundations, and trade associations, $12.4 million; foundations and charitable trusts, $16.0 million; others, $0.2 million. Included in the totals for alumni and

friends are gifts of $1.1 million made to the Maclaurin Pooled Income Fund and the William Barton Rogers Pooled Income Fund. The total income of $5.5 million for corporate liaison programs represented a 20 percent increase over the total for fiscal year 1981.

Donors designated expendable and endowed funds as follows: unrestricted, $5.4 million; departments, $13.0 million; faculty salaries, $7.2 million; graduate scholarships and fellowships, $1.9 million; undergraduate grants, awards, and loan funds, $1.6 million; building construction funds, $4.5 million; other funds, $0.2 million.

Corporation Development Committee

The members of the Corporation Development Committee continued to provide assistance in identifying and acquiring new resources for the Institute during the post-campaign period.

The annual meeting of the Committee was held on October 30, with 65 members in attendance. The morning session was devoted to financial reports -- including the Institute's finances, funding priorities, the cost of endowed chairs, and the effect of the Economic Recovery Tax Act of 1981 -- and to reports on the MIT Sustaining Fellows, the National Business Committee, and the Leadership Gifts organization.

After luncheon in the Ashdown House dining room, the Marshall B. Dalton Award for exceptional service to MIT was presented *in absentia* to Hugh Parker, Class of 1943. Mr. Parker, who lives in London, has served as president of the MIT Club of London and has been a key figure in building the Industrial Liaison Program's membership and activities in the United Kingdom.

The afternoon session featured two programs: a lively student-faculty presentation on the Undergraduate Research Opportunities Program (UROP), under the direction and guidance of Professor Margaret MacVicar, and a firsthand report from Provost Francis E. Low on discussions concerning the Whitehead Institute for Biomedical Research.

We note with deep regret the death of Thomas F. Morrow, Class of 1935, an honorary member who was active on the Committee from 1969-1981.

Development Office

The Development Office continued to expand its use of automation and computerization in maintaining the central databank for MIT's development activities. A terminal was linked to the Industrial Liaison Program's electronic mail system; new information management systems were developed; and the use of word processing and computerized information retrieval were stepped up, to provide faster and more comprehensive service to senior officers, faculty, and Resource Development staff. To enable better exchange of information regarding corporate and foundation grants and contracts, coordination between the Development Office and the Office of Sponsored Programs has been increased.

Development Office staff members continued to identify and evaluate major donors and prospects, recommend funding strategies, and coordinate contacts with prospective donors. Considerable time was spent in support of the microsystems, arts and media technology, and health sciences programs, and in helping develop a funding plan for the Department of Economics, which is seeking to become less dependent on National Science Foundation (NSF) fellowship support. Staff time was also devoted to developing funding strategies for the renovation of the chemistry laboratories, for a proposed brain sciences building, for the Center for Engineering Design, and for the completion of funding for the Future of the Automobile Study.

Foundation Support

Staff responsibility for foundations (private and corporate) remained under the direction of Dr. Vincent C. DeBaun, director of the Development Office, with the assistance of the associate and assistant directors. Cultivation of foundations focused on support for the health sciences (particularly biotechnology), for financial aid to graduate students, and for the retention of young faculty in science and engineering.

Health Sciences

The scope of the Institute's commitment to educational and research programs in the health sciences has grown steadily over the years. With Federal funds diminishing, private support for these activities has become increasingly important. As a result, in August 1981, Barbara Gunderson Stowe joined Resource Development to direct a comprehensive fund-raising effort on behalf of MIT's health sciences programs.

Over the course of the year, Ms. Stowe directed her attention toward developing and defining funding needs, working with faculty in identifying and evaluating projects, and strengthening and expanding contacts with current and prospective donors. Her newly integrated responsibilities include efforts on behalf of Whitaker College, the Center for Cancer Research, the Eric P. and Evelyn E. Newman Laboratory for Human Mechanics and Rehabilitation, brain sciences programs, and other interdisciplinary centers and laboratories.

Communications

The Office of Communications, under the direction of Deborah J. Cohen, provided written materials in support of many of the Institute's major funding efforts. Among the publications issued were: a revised edition of *Financial Aid for Undergraduates at MIT*, *Gift Opportunities at MIT*, (a listing of funding needs throughout the Institute), and *The Case for MIT -- Why Give?*, a statement by President Gray.

Donor relations activities included a greatly expanded program of reporting on the uses of past gifts, assistance in the process of clearing press releases on major gifts, and assistance to various Institute departments in organizing special events. Included among this last group was participation in the dedications of the Whitaker College and Medical Department complex and the H.H. Uhlig Corrosion Laboratory.

Planned Giving

Of the $12,468,495 in gifts and bequests from alumni and friends, 58 percent -- described as planned gifts -- came through gifts involving the efforts of D. Hugh Darden and Thomas R. Henneberry, director and associate director, respectively, of the Office of Planned Giving and Legal Affairs. All efforts were in closest coordination with senior and other officers, faculty, and staff (especially Donald P. Severance, director of Leadership Gifts), District Directors, and Alumni Association and Fund staffs (especially Nancy L. Russell, associate director of the Alumni Fund).

A pamphlet, "Looking for a Good Investment?", was mailed to over 7,500 members of classes anticipating major reunions. A record 16 planned giving meetings were held at various locations in connection with reunion gifts and leadership gift efforts.

	Donors	Dollars
Outright gifts generated by Program	71	$2,258,191
Separately invested unitrusts	3	226,363*
William Barton Rogers Pooled Income Fund	4	58,643
The Maclaurin Pooled Income Fund	45	1,051,922
Receipts from Bequests, testamentary and other trust arrangements	68	3,597,275
TOTAL	191	$7,192,394

*In addition, seven new trusts were established outside MIT and are appropriately reflected in the trust table which follows.

As of June 30, 1982, 1,199 notifications of plans for future gifts, including irrevocable trusts in which the Institute now has a vested future interest, were on record with the Institute. During the year, 35 estates and outside trusts were closed and fully distributed (amount included in table above). Irrevocable trusts totaled 316 (see table next page).

	Number	Dollars (Current Market Value)
Trusts held by MIT	182	$ 9,401,509
Trusts held outside MIT	134	23,923,850
TOTAL	316	$33,325,359

During the year, six trust funds held by the Institute totaling $278,282 were closed and transferred over free of trust for Institute purposes.

The Economic Recovery Tax Act of 1981 made substantive changes in Federal income, estate, and gift tax laws. The impact of these changes may not be as negative as predicted by some commentators. Policies and procedures for soliciting and taking in gifts of equipment were clarified and announced in cooperation with the Treasurer's Office.

Leadership Gifts

Several hundred Leadership Gift volunteers were supported by the three district directors, under the leadership of Mr. Severance, Class of 1938, and the staff of the Office of Planned Giving and Legal Affairs. Nearly 1,100 personal visits were made to prospective donors by volunteers and staff, singly and in teams.

The Leadership Gift organization helped identify new leads for the National Business Committee; became increasingly involved in promoting new memberships for the Sustaining Fellows Program; worked closely with the Alumni Association in the solicitation of major prospects for class reunion gift programs; and worked with the Office of Planned Giving and Legal Affairs program in organizing and conducting meetings with alumni interested in life income plans and other creative forms of making capital contributions.

Two new publications, *The Case for MIT -- Why Give?* (a statement by President Paul E. Gray), and *Gift Opportunities at MIT*, proved most helpful in our endeavors.

Currently the Leadership Gift rolls include 1,400 individuals who have been identified as possible leadership prospects. For 1982-83, staff will concentrate on those known to be of greatest potential, and will give greater emphasis to solicitations by or with volunteers rather than solicitation by staff alone.

We again express our deepest appreciation for the able guidance and dedication of John Reed, Class of 1961, chairman of the Leadership Gifts committee, and our many devoted alumni volunteers.

MIT Sustaining Fellows

The MIT Sustaining Fellows program, directed by E. Barbara Lewis, completed its third year of operation as MIT's central program for recognizing, involving, and cultivating major benefactors of the Institute. Membership in the program now exceeds 560; the ratio of life members to annual members remains two to one. The Sustaining Fellows Fund, which is generated by the Fellows' unrestricted gifts, totaled $177,000 for 1980-81 and was designated by President Gray for automation of the MIT Libraries' circulation system. The project will also benefit from the Sustaining Fellows Fund income for 1981-82.

Efforts to involve members more closely with the Institute continued. Fellows were again invited to all Industrial Liaison Program symposia and seminars, and Boston-area Fellows were invited to concerts and exhibitions on campus. Three regional gatherings included Dr. Gray as honored guest: a reception in Chicago hosted by Karl Van Tassel, Class of 1925; a luncheon in San Francisco co-hosted by Paul M. Cook, Class of 1947, George M. Keller, Class of 1948, and Denman K. McNear, Class of 1948; and a luncheon in Palm Beach hosted by Alex W. Dreyfoos, Jr., Class of 1954.

The MIT Sustaining Fellows held its first major event in Cambridge, on October 30, with more than 400 people attending a reception and dinner. The Vice President of the United States, George Bush, was guest speaker.

Breene M. Kerr, Class of 1951, and a member of the MIT Corporation and its Executive Committee, continued his effective leadership as Sustaining Fellows chairman; Professor Elias P. Gyftopoulos continued his role as the faculty chairman. Howard W. Johnson, chairman of the MIT Corporation, and President Gray remained honorary chairmen.

Corporate Relations

Despite the difficult economic climate, the National Business Committee (NBC) continued its efforts to acquire financial support for MIT from business and industry. Members and associates arranged 28 visits at corporations, and an additional 12 corporate visits took place at MIT. Several other proposals were made on the basis of telephoned or written introductions to companies by NBC members. In substance, the performance of the previous year was equaled, but marked improvement will probably not occur until the economy turns around.

The Corporate Relations staff increased efforts to identify and meet with alumni judged able to arrange good corporate introductions. In addition, meetings were held with individual NBC members to review corporate prospect lists and to encourage their acceptance of new assignments. NBC members, together with 28 associate members, are now assigned a record 180 companies.

Over its five-year history, the NBC has concentrated mainly on the solicitation of industrial companies. This is now changing, with approaches including areas such as retailing, financial services, and other non-industrial concerns. It is too early to determine how successful such efforts will be, but the few visits which have taken place indicate encouraging potential.

Effective July 1, 1982, Robert L. Mitchell, Class of 1947 (Graduate School) and vice chairman of Celanese Corporation, succeeds Richard L. Terrell, Class of 1958 (Senior Executives Program), as chairman of the NBC. Mr. Terrell has served as chairman since the inception of the NBC in the fall of 1976, and has provided vital leadership during the Leadership Campaign and the post-campaign period. We have been privileged to work with him, are deeply grateful for all he has accomplished, and are very pleased that he will continue to serve as a committee member. We are most fortunate to have an excellent successor in Mr. Mitchell.

The NBC effort was staffed by Robert Hagopian, director of Corporate Relations, and Jacquelyn M. Findlay, assistant director.

Industrial Liaison

On July 1, 1981, the Associates Program was formally merged into the Industrial Liaison Program (ILP), and the past year was the first full year of combined operation. This year also marked the implementation of a computer-based office system, which holds significant promise for enhancing the productivity and extending the capabilities of the ILP staff. Gross revenues for fiscal year 1982 reached $5,540,500, a 20 percent increase over last year. Total membership as of June 30 was 281 companies. Members included 41 companies in Europe and 33 in Japan. Membership has now been extended to Venezuela, where two companies recently joined.

Program services expanded significantly during the year. Program staff arranged more than 1,700 visits on and off the campus, and the Office of Information Systems (ILP/OIS) was instituted to help provide companies with better service. The ILP/OIS began full-scale support of the staff on July 1, 1981, with a computer-based system including capabilities for database management, text processing and formatting, electronic mail and file handling, and numerical data processing.

Among other major developments was a new newsletter, *The MIT Report*, which evolved from the combination of the ILP's "Monthly List of Publications" with "Reports on Research." The new publication features a larger, updated format as well as expanded content. The ILP Publications Office, in conjunction with ILP/OIS, implemented an on-line publications database

consisting of 25,000 records containing reference information on technical manuscripts and working papers by MIT faculty and staff. In addition, the *Directory of Current Research (DCR)* was edited and updated on the ILP computer for the first time.

The year's seminar program included: 16 US presentations by MIT faculty members, with total attendance of nearly 2,200; seven seminars in Europe, with a total attendance of approximately 160; and 20 seminars in Japan, with a total attendance of 525.

The ILP also sponsored several short courses. The intensive course "VLSI Design" was held in Cambridge in June with an attendance of 30; "Personal Computers, Networks, and Office Automation" attracted nearly 90 attendees in Paris in February; and some 80 persons attended "Fermentation Technology," also in Paris in February.

A major symposium for senior executives, led by President Gray and entitled "The Innovative Process: Evolution vs. Revolution," was held in London in November with an attendance of approximately 120. A colloquium, "Microcapsules and Microcarriers in Biotechnology," was held at MIT in October with an attendance of 270.

A well-defined fee-sharing arrangement between the ILP and other MIT organizations was set up to encourage members to join the other various industrially sponsored programs conducted under the auspices of several MIT laboratories, centers, and departments.

Sincere thanks are due to all of the faculty and staff who have participated in the Industrial Liaison Program's activities during the past year. The spirit of cooperation has been essential to the success of the program and is gratefully appreciated.

Staff Changes

Early in the year, Dr. John E. Oldham was appointed assistant director in the Development Office.

Barbara Gunderson Stowe was appointed health sciences development officer.

Several staff changes were made in the ILP. Susan I. Shansky was promoted to manager of publications. Peter N. Cerundolo, Gary J. Des Groseilliers, Robert R. Lockett, and Katherine E. Van Sant were appointed Industrial Liaison officers. Industrial Liaison officers Jerry R. Horton and Jane E. Martini resigned, the former to pursue a Ph.D. in Chemical Engineering at MIT and the latter to relocate to London. Ben Inouye succeeded George K. Sankey as director of the MIT-ILP Japan Office. Mr. Sankey became special assistant to the Vice President for Resource Development. Maureen P. Hedden, Programmer/Analyst, resigned to continue studies at Boston University.

Conclusion

The next three years will test Resource Development's ability to meet the increasing needs of the Institute in an ever more competitive environment and, unfortunately, in a depressed economy. Our traditional links to industry, inspired by the original charter of the Institute, have proved particularly auspicious in recent years. We must, however, maintain active fund-raising efforts throughout the private sector.

In closing, I would like to express my thanks to all the members of Resource Development, and to the senior officers of the Institute. It is a joy to work with them. Special thanks are due to the several Presidents Emeritii who continue to aid in the vital function of the "nutrition of the Institute through the greening process."

I also want to acknowledge the continuing and remarkable effectiveness of Dr. Irwin W. Sizer -- a superb colleague, mentor, and friend.

SAMUEL A. GOLDBLITH

Lincoln Laboratory

Lincoln Laboratory is operated by MIT as a Federal Contract Research Center for performing research and development in advanced electronics. During the past year, agencies of the Department of Defense (DOD) -- the Air Force, Army, Navy, and the Defense Advanced Research Projects Agency (DARPA) -- supplied 95 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 1982 the operating budget was $178 million, supporting the efforts of 776 professional staff, 76 percent of whom hold advanced degrees.

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. The photovoltaic program was substantially completed during the year. Highlights of accomplishments during the past year are summarized below.

Millimeter-Wavelength Instrumentation Radar for Kwajalein

The objectives of the millimeter-wavelength instrumentation radar program are to design, construct, and install at the Kwajalein Atoll an instrumentation radar operating at 35 GHz and 95 GHz. This radar will not only serve as a test bed for radar system technology in these new frequency regions, but will also collect active and passive signature data to provide a database for future developments of millimeter-wavelength radar systems. In addition, characterization of atmospheric effects in millimeter-wavelength propagation will be required to accurately measure the radar observables.

During the past year, major subsystems of the radar have been shipped to Kwajalein. Its realization is made possible by the successful development of many components not previously available. Among these are the following:

- A 35-GHz, 30-kW peak power traveling-wave tube amplifier, with coupled cavities as an output circuit
- A dual-frequency, high-power radar feed, using multi-waveguide modes for high efficiency
- Duplexers and receiver protectors operating at 95 GHz and using switchable ferrits
- A 95-GHz radiometer, which employs a continuous-comparison approach to cancel sky background fluctuations. A one-second integration sensitivity on the order of 0.05 degrees Kelvin has been achieved.
- A 13.7-m diameter antenna system, consisting of 72 individual reflector panels, which has a surface tolerance of better than 0.1 mm rms
- A 95-GHz, 6-kW peak power amplifier, which will be completed within the next year

Upon completion of installation and checkout early in 1983, a high-power, coherent, millimeter-wavelength instrumentation radar with a range resolution of 0.25 m and an ultra-sensitive radiometer will be available for measurement operations. Lincoln Laboratory personnel will then be able to couple atmospheric measurements with radar observables to provide high-quality calibrated data to support the development of future millimeter-wavelength radar systems.

Jam-Resistant Secure Voice Communication

The ability to maintain communications among aircraft and between aircraft and ground stations is essential to the effective conduct of tactical air operations. For the past several years the Laboratory has been engaged in a program to develop jam-resistant secure voice communication (JRSVC) techniques. A high degree of jamming resistance has been achieved by the combination of two band-spreading techniques, frequency hopping, and pseudo-noise. Communication security results from secure, time-synchronized key generators at the transmitter and receiver which scramble and descramble the digitized voice signal.

Key issues in the development of these techniques have been the ability to synchronize and decode these highly complex signals in compact, affordable equipment, and the ability for a receiving terminal to listen to several signals simultaneously.

Critical components in the waveform decoding are miniaturized, fast-switching frequency synthesizers and a 512-stage programmable matched filter, which is fabricated using charge-coupled device techniques. The charge-coupled device matched filter was developed jointly by the Laboratory and RCA.

Special techniques developed to permit conferencing (the ability to listen to more than one signal at a time) include signal and associated decoder designs which permit the efficient, simultaneous decoding of several spread-spectrum signals.

The principal elements of the JRSVC design have recently been adopted by the Air Force for its next generation of voice communication radios.

Optical Atmospheric Compensation

The optical atmospheric compensation program has as its application the efficient propagation of optical signals from ground to space for communication purposes. In early 1982, a laboratory investigation of adaptive optical correction for atmospheric turbulence effects on laser propagation was completed. The adaptive optics system consists of a radial grating shearing interferometer, an analog wavefront reconstruction circuit, analog servo circuitry, high-voltage drivers, and a monolithic piezoelectric deformable mirror. The detectors in the interferometer are photomultiplier tubes, and the phase sensor has demonstrated sensitivity near the photon-shot-noise limit.

The experimental system has been working reliably following the completion of system integration and the correction of a number of cross-talk difficulties. Typically, the residual wavefront error is as low as 0.025-0.04 wave (rms) in cases where the input wavefront error is approximately 0.5 wave (rms). This performance greatly exceeds the 0.1 wave performance which was anticipated.

Presently, the adaptive optics system is being installed at the DARPA Maui Optical Site for an extensive field measurement series. The series will include measurements on a ground range, propagation measurements to an instrumented aircraft, and tests with instrumented rocket-borne packages.

Optical Signal Processing

The Laboratory has been developing several different solid-state devices which harness the capabilities of light for performing high-speed signal processing.

A unique electro-optic analog-to-digital converter has been demonstrated with fast sampling and conversion at a 4-bit, 800-megasample/sec rate, thereby setting a new record for the bandwidth of A/D converters. The electro-optic A/D converter uses short laser pulses for sampling. These pulses are guided by an integrated optical array of lithium niobate and titanium-indiffused waveguide interferometric modulators which perform the conversion. Germanium avalanche photodiodes are used for detection, and a special 1-GHz silicon integrated circuit provides fast comparison and interfacing with conventional digital circuits.

Photoconductive devices have been developed which function as optically controlled circuit elements with complete isolation of the control signal from the electrical input. Such devices fabricated on semi-insulating indium phosphide and operated with short laser pulses provide the attractive

features of low on-state resistance at modest light levels (approximately 1mW), very high off-state resistance, and fast response (approximately 100 ps). Demonstrated applications include high-speed samplers, highly linear mixers with no DC offset and minimal local oscillator leakage, and broad-band modulators.

The Laboratory also has begun the development of a new type of spatial light modulator which can be addressed electrically at high speeds. Among other applications, such a device can exploit the capability of a lens to perform large, two-dimensional Fourier transforms. The modulator is in the form of a two-dimensional charge-coupled device array in gallium arsenide. Experiments have shown that for photon energies slightly lower than the energy gap, the transmission through the charge-coupled device structure may be controlled by the signal charge in the wells. This mechanism promises the combined features of high-speed operation and good optical uniformity.

Permeable Base Transistor

Major progress has recently been made in the development of the permeable base transistor (PBT). The device, conceived at Lincoln Laboratory, utilizes a thin-film tungsten grating of submicrometer periodicity to form a narrow base region. The PBT is expected to have important applications as a high-frequency (>100-GHz), small-signal amplifier; as a power amplifier (5 W) up to about 50 GHz; and as a very fast (approximately 10-ps), low-power (30-microwatts) logic element for very high speed integrated circuits. Both silicon and gallium arsenide PBTs are currently being developed.

Gallium arsenide PBTs with a maximum stable gain of 16 dB at 18GHz and an extrapolated maximum frequency of oscillation beyond 100 GHz have been fabricated. Improvements in device construction are expected to raise performance to a level beyond that attained by any other three-terminal device.

The PBT is being developed in a program to establish the technology for an integrated 10-GHz bandwidth packet radio transceiver. The new results provide confidence that this and numerous other microwave and digital circuit applications can be implemented with the PBT.

Silicon-On-Insulator Technology

The Laboratory is developing techniques for preparing large-area silicon-on-insulator (SOI) structures and for utilizing these structures in the fabrication of large-scale integrated circuits. An SOI technology would have several important advantages over conventional silicon integrated-circuit technology, including higher packing density, increased speed, and improved radiation resistance.

To prepare the SOI structures, a commercial silicon wafer is coated with a thin insulating layer of silicon dioxide, a silicon film is deposited on the silicon dioxide, and the film is encapsulated with one layer each of silicon dioxide and silicon nitride. The silicon film, which is initially too fine grained to be device worthy, is then recrystallized by passing a graphite resistance heater over the surface, causing a narrow molten zone to traverse the film. The process has been developed to the point where films on three-inch diameter wafers can be successfully recrystallized over most of their areas.

In initial device studies, metal-oxide semiconductor, field-effect transistors have been fabricated in the recrystallized silicon films. The characteristics of these transistors are comparable to those of conventional bulk silicon devices and are far superior to those of devices using silicon-on-sapphire structures, the only SOI structures now commercially available. Furthermore, if a moderate bias voltage is applied to the silicon substrate, the new SOI transistors are much less sensitive to ionizing radiation than silicon-on-sapphire devices. On the basis of these encouraging results, the SOI development program is being extended. The next steps in the program will be to perfect the recrystallization process and concurrently begin fabricating functional integrated circuits for evaluation.

Infrared Airborne Radar

The purpose of the infrared airborne radar program is to develop technology which utilizes coherent carbon dioxide laser imaging radars, both pulsed and cw, for ground observation under nighttime and poor-visibility conditions. During the past year a transportable, ranging (pulsed) radar system has been used for field experiments. A recent development has also been the detection of radar signal returns from naturally occurring atmospheric aerosols as a means of surveillance for the presence of chemical contaminants.

Progress has been made in developing image-processing computer algorithms than can automatically detect the presence of vehicles using active imagery. A limited amount of vehicle recognition also has been demonstrated.

A cw carbon dioxide laser radar has been used to make measurements of ground and moving vehicle signatures. Imagery made with this system shows great promise for good vehicle detection and classification capability through the use of features associated with moving parts on vehicles.

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 100 members of the Corporation included 75 active members, 24 life members emeriti, and one member-elect due to assume office at the October 1, 1982 annual meeting of the Corporation. There were 23 individuals whose membership status changed during 1981-82 in a year of very high activity for the Membership Committee.

At its June 1, 1982, meeting, the Corporation elected the following members to life membership, effective July 1, 1982: W. Gerald Austen, Class of 1951, Chief of the Surgical Services, Massachusetts General Hospital; and W. Van Alan Clark, Jr., Class of 1942, Chairman, TSC Corporation, both of whom had served two previous, consecutive five-year terms. Also elected to life membership was Kenneth J. Germeshausen, Class of 1931, Director and Consultant, EG&G, Inc., who became a member of the Corporation in 1980.

At its June 1982 meeting, the Corporation further elected the following members to five-year terms, effective July 1, 1982: Yaichi Ayukawa, Class of 1952, President, Techno-Venture Company, Ltd.; David R. Clare, Class of 1945, President, Johnson & Johnson; Bernard W. Harleston, President, City College of New York; David I. Kosowsky, Class of 1952, President, Damon Corporation; Angus N. MacDonald, Class of 1946, President, Angus MacDonald & Company, Inc.; Jerry McAfee, Class of 1940, former Chairman and Chief Executive Officer, Gulf Oil Corporation; E. Kirkbride Miller, Class of 1941, Chairman of the Board, T. Rowe Price Associates, Inc; Rita A. O'Brien, Class of 1977, Vice President, New England Telephone Company, Rhode Island; Frank Press, President, National Academy of Sciences; and Edward T. Thompson, Class of 1949, Editor-In-Chief, *Reader's Digest*. Frank S. Wyle, Class of 1941, Chairman of the Board, Wyle Laboratories, was elected a member for three years at the same meeting, to complete the term vacated by Mr. Germeshausen in his advancement to life member. Heidi R. Wyle (no relation), Class of 1980, a doctoral student in the Department of Nuclear Engineering, was elected a member at the same meeting to a five-year term, effective October 1, 1982.

In addition, Denman K. McNear, Class of 1948, Chairman and Chief Executive Officer, Southern Pacific Transportation Company, Inc., who served an earlier five-year term as a member of the Corporation, 1977-82, assumed an ex-officio position on the Corporation by virtue of his selection as the 1982-83 President of the Alumni Association. In that position, he succeeds Mr. MacDonald, effective July 1, 1982.

Our life members, Helen F. Whitaker, Trustee of the Whitaker Health Sciences Fund; and W.B. Murphy, former President, Campbell Soup Company, transferred to emeritus status during the year. Mrs. Whitaker continues as a member of the Whitaker College Visiting Committee and as a trustee of the Whitaker Health Sciences Fund. She has served with distinction as a member of the Corporation since 1976 and as a life member since 1979. The seminal role which she and U.A. Whitaker have played in fostering the development of the health sciences and improved health care at the Institute was recognized by the Corporation at its March 1982 meeting, in connection with the dedication of Whitaker College of Health Sciences, Technology, and Management.

The transfer of Mr. Murphy to life member emeritus was marked by the designation of Mr. and Mrs. Murphy as guests of honor at the Corporation Commencement luncheon on June 1. Mr. Murphy became a term member of the Corporation in 1961 and a life member in 1965. He and his associates at Campbell Soup Company were instrumental in fostering the growth of the Department of Food Technology at MIT in the early 1950s and the reorganized Department of Nutrition and Food Science in 1961. For many years he served as chairman of the Visiting Committee for that Department, and he continues as a member of its Visiting Committee. During the past two decades Mr. Murphy served 12 years on the Executive Committee of the Corporation and nine years as a member of the Sloan School Visiting Committee, and he also chaired the Sloan School Committee, 1963-65. He served as a member of the Membership Committee, 1964-67, and was one of the co-chairmen of the MIT Leadership Campaign from 1977 to the completion of the Campaign in 1980. In these and other ways he has distinguished himself, and he has made an enduring contribution to MIT's well-being. The Institute is exceedingly fortunate to have a national leader of his stature in the food industry in its governing body on a permanent basis.

The Corporation was saddened by the deaths of James B. Fisk, life member and former President of Bell Telephone Laboratories, on August 10, 1981; Edward J. Hanley, life member emeritus and former Chairman and President of Allegheny Ludlum Steel Corporation, on March 13, 1982; and Charles Allen Thomas, life member emeritus and former Chairman and President of Monsanto Company, on March 29, 1982. It is not possible to convey the magnitude of their lifetime contributions to the Institute. Dr. Fisk, a member of the Class of 1931, was 71 years of age but for three weeks when he died in Elizabethtown, New York. He had served for 22 years on the Corporation, including 18 years as a life member. His continuous 19-year tenure (1962-81) in the Executive Committee exceeded that of any Corporation member in MIT's modern history, except for certain officers of the Institute.

Mr. Hanley, a member of the Class of 1924, was 79 years of age when he died in Pittsburgh. He had served for 26 years on the Corporation, including 21 years as a life member. In 1959-60 he served as President of the MIT Alumni Association. He served 10 years as a member of the Executive Committee and 12 years on the Investment Committee, and was active in other Standing and Visiting Committees.

Dr. Thomas, a member of the Class of 1924, was 82 years of age when he died at his winter home near Albany, Georgia. He had served for 32 years on the Corporation, including 27 years as a life member. During his long tenure he served on numerous Visiting Committees and participated actively in fund drives for the Institute.

The lengthy resolutions of the Corporation on these three deaths are a matter of record. The details of trusteeship by each deceased Corporation member are included in those resolutions. The total of 80 years of dedicated service invested in the Institute by Dr. Fisk, Mr. Hanley, and Dr. Thomas speaks for itself in glowing, monumental terms. We shall miss them mightily, each of them.

Expiration of term membership has cost the Corporation the formal services of Vincent S. Castellano, Class of 1977, Associate, Private Financing Department, Goldman Sachs & Co.; Charles G. Koch, Class of 1957, Chairman, Koch Industries; F. Richard Meyer, III, Class of 1942, Consultant in corporate mergers and acquisitions; and David S. Saxon, Class of 1941, President, University of California, Systemwide Administration. These retiring Corporation members continue their association with the Corporation in many ways as members of various alumni, Corporation, and Institute committees.

Effective January 1, 1982, John H. Lawson became Commissioner of Education of the Commonwealth of Massachusetts and an ex-officio member of the Corporation. We welcome Dr. Lawson, formerly Superintendent of Schools in Lexington, Massachusetts, to the Institute's governing body.

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 the year to a continuing study of CJAC's potential role in the Institute's governance. CJAC met twice as a full committee and its chairman held other discussions with the senior officers of the Institute and student members of the committee in an effort to develop a consensus about an appropriate modus operandi. It was determined that CJAC would be kept in operation as a committee of the Corporation and that the issues it might examine would be established at the beginning of each year through an agenda-setting discussion between the ex-officio members of CJAC and the senior officers of the Institute. This plan provides for CJAC to become inactive for the balance of the year if no agenda topics are deemed appropriate for the committee to pursue. The writer wishes to acknowledge the sensitive leadership of our Corporation member, Claude W. Brenner, who served as chairman, and the assistance given to CJAC by Iris E. Lazarus of this office, who also served as voluntary 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 an afternoon colloquium chaired by Provost Francis E. Low on October 2, 1981, in honor of faculty members who hold distinguished appointments to Institute professorships and to named and endowed professorships; a dinner in the Tapestry Gallery of the Museum of Fine Arts on December 3, 1981, to mark the completion of renovated facilities at 70 Memorial Drive, Cambridge, for the Program in Science, Technology, and Society; the dedication of the undergraduate residence, 500 Memorial Drive, at the Corporation luncheon on December 4, 1981; the dedication that same afternoon of the MIT Athletics Center in the ice skating rink, with Irenée du Pont, Jr., serving as dedication speaker and President Paul E. Gray and many others participating in the program (which included a tribute to Clint W. Murchison, Jr., for his leadership of the National Sponsoring Committee for the Athletics Center); the afternoon dedication on March 5, 1982, in Room 10-250 of the buildings for Whitaker College of Health Sciences, Technology, and Management and the Medical Department Health Services Center, at which Mrs. Whitaker, President Gray, Frederick C. Robbins (President of the Institute of Medicine), and Drs. Irving M. London and Melvin H. Rodman spoke; the ground-breakings for the Arts and Media Technology building and the new conference center at Endicott House; and others.

At the December 4, 1981, Corporation luncheon, Chairman Johnson announced the decision of the Corporation to name House No. 1 in the New West Campus Undergraduate Houses in memory of James B. Fisk and House No. 6 in the same complex in honor of George W. Thorn. Both Dr. and Mrs. Thorn and several members of Dr. Fisk's family were present at the luncheon. At the March 5, 1982, dedication of Whitaker College, Chairman Johnson also uncovered portraits of Mr. and Mrs. Whitaker and announced the naming of several rooms within the College in memory of Albert O. Seeler and in honor of Irwin W. Sizer, Dr. Thorn, AMP Incorporated, and others. Departmental dedications during the year included the Herbert H. Uhlig Corrosion Laboratory and the new doors to the Massachusetts Avenue entrance of the Guggenheim Laboratory in Building 33.

Corporation Development Committee

The report of the staff organization to support the 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 Corporation members on the Council on Resources of the Institute, Corporation Development Committee (CDC), and Alumni Fund Board. In addition, many members of the Corporation have headed or are serving as members of National Sponsoring Committees for professorship endowment projects or facilities.

Breene M. Kerr continued his role as chairman of the MIT Sustaining Fellows. Several Corporation members served as hosts at regional luncheons for the Sustaining Fellows. Richard L. Terrell completed his sixth and final year as the founding chairman of the National Business Committee, seeking major grants from US and foreign corporations. Jerome B. Wiesner continued as chairman of the Council for the Arts at MIT; Gregory Smith continued as chairman of the Arts Council's Development Committee; and the Arts and Media Technology Facility's Sponsoring Committee includes a number of Corporation members. In Japan, Mr. Ayukawa continued to serve as a central figure in organizing support by the Japanese government and Japanese companies. Mr. McAfee led a drive to secure endowment and operating support for the Chemical Engineering Practice School. Corporation Development Committee member Hugh Parker, of London, received the 1981 Marshall B. Dalton Award of the CDC 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 a clear demonstration by the Institute's governing body of its commitment to secure the necessary resources for MIT's continued independence and strength in the years following the successful completion of the MIT Leadership Campaign. The Institute will always be grateful to the above named and to the Corporation as a whole.

This year's achievement included an encouraging total of more than $45 million in cash gifts, grants, and bequests receipts from the private sector. Despite the recession in the national economy, it was the Institute's second best year on record in terms of private support.

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 Low called upon all segments of the Institute community to continue the budget limitations that are necessary for planning a future balanced budget. In addition, through its various committees, the Corporation played a key role in communication with students, faculty, alumni, and the general public on the range of questions and issues before MIT.

Special thanks are due once again to the Ad Hoc Committee on Shareholder Responsibility, under the chairmanship of D. Reid Weedon, Jr., for its continuing assistance to the Executive Committee of the Corporation. Walter L. Milne, Assistant to the President and the Chairman of the Corporation, served again as Secretary to the Committee on Shareholder Responsibility.

Additional thanks are due the Corporation Screening Committee, under the chairmanship of David R. Wilson, 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 notable actions, the Corporation voted at its annual meeting on October 2, 1981, to discontinue the S.M. Degree in Interdisciplinary Science for lack of enrollment, and to dissolve the Arts Visiting Committee after 10 years because its functions duplicated somewhat the responsibilities of the now mature Council for the Arts at MIT. It was decided that the arts-related educational concerns at the Institute were better handled within the context of the appropriate Visiting Committees to particular departments. At its annual meeting, the Corporation also voted to change CJAC's status from that of an active committee of the Corporation to that of a standby committee of annual recurrence. The student members of CJAC subsequently asked for a modified basis for the committee, which will permit meetings to be held more frequently than once a year, if agenda items warrant.

In other notable actions, the Corporation voted at its December 4, 1981, meeting, after extensive discussions during the preceding year, to accept the recommendation of the faculty and the Executive Committee to approve the formal affiliation between MIT and the Whitehead Institute for Biomedical Research. In reaching this vote, the Corporation also adopted the following resolution:

> The MIT Corporation deeply appreciates the comment and debate provided by the faculty of MIT on the question of the affiliation between MIT and the Whitehead Institute for Biomedical Research, which were of great assistance in its deliberations, and acknowledges the concerns voiced by members of this faculty.

At its June 1 meeting, the Corporation voted to establish a new S.B. Degree in Cognitive Science, to be recommended by the Department of Psychology. The new bachelor's degree marks the first time in its 20-year history that the Department will offer an undergraduate program. At the same meeting, Chairman Johnson announced the formation of an Ad Hoc Committee on Information Transfer, under the chairmanship of Edward O. Vetter, to examine a range of issues raised by President Gray in his March presentation to the Corporation on export controls, technology transfer, commercialization of research, and related matters. At the June 1 Commencement Exercises which followed in Killian Court, Chairman Johnson welcomed Katharine Graham, Chairman of the Board of the Washington Post Company -- the first invited speaker outside of MIT to address the graduating class in 19 years and the first woman to serve as Commencement speaker since the founding of the Institute.

The year 1981 marked the beginning of the participation of Professor Felix M. H. Villars, Chairman of the Faculty, in the regular meetings of the Corporation. The Corporation expresses appreciation to Professor Villars and to Provost Low who contributed significantly to the discussions in Corporation meetings during the year.

Corporation Visiting Committees

The year 1981-82 was one of sharply increased activity for the Corporation Visiting Committees. Compared with 14 of the 28 Committees which met during each of the preceding two years, 20 meetings were held in 1981-82. The chairmen of the Visiting Committees for the departments of the School of Engineering did not meet in 1981-82 as they did in 1979-80, due to the change in the deanship on August 1, 1981. The new Visiting Committee for the Whitaker College of Health Sciences, Technology, and Management held its first meeting on December 10 and 11, 1981, under the chairmanship of Mr. Austen.

These 20 meetings in 1981-82 involved an average attendance of 12 members each, or roughly one-half of the total Visiting Committee membership, which now exceeds 550 members. This increased level of Visiting Committee activity was in keeping with a guideline set by the Corporation during its March 6, 1981, meeting to increase Visiting Committee meetings to a 12- to 18-month cycle from the 24-month cycle followed during the years of the MIT Leadership Campaign. Thus, we plan to maintain a level of about 20 meetings a year, evenly divided between the fall and spring semesters. The calendar for 1982-83 was started in this direction, with 10 of the Visiting Committees and one subcommittee meeting scheduled to meet during the coming fall semester.

I want to recognize the olympian dedication of Mary S. Miller, Administrative Secretary in the Corporation Visiting Committee Office, for the painstaking task of scheduling and staffing these meetings. At the beginning of the year she succeeded Cara T. Cameron who left for family responsibilities. I thank Mrs. Cameron and wish her well. Ms. Miller has brought renewed strength and quality to the management of Visiting Committee activity.

Several features of the meetings which have proved successful in the past were continued by the Visiting Committees this year. All of the 20 meetings included dinner at which the members were brought together informally with the faculty and administration. Also, the Committees made effective use of private sessions with students on their agenda, further formalizing this additional and valuable means of gaining insight into departmental activities. A number of the Committees for larger departments included similar separate sessions with junior faculty. Discussions with each of the departments had many common interests, including systematic follow-up of previous Committee recommendations and reviews of departmental progress in recruitment of minorities and women as students and faculty members.

Attendance by members of the Visiting Committees has been excellent this year, save for the meetings held during December and January winter weather. In addition, the participation in this year's series of meetings by the senior officers and deans of the Institute continued at a high level. The presence of these officers at the various meetings enhances the interchange between the committee and the department and often provides a welcome catalytic effect which contributes to the success of the meeting. Enduring thanks are due Provost Low for his diligent participation in all of the meetings, and to the more than 400 faculty members who participated in the sessions of the Visiting Committees.

Of the Committees meeting in the 1980-81 year, all of the chairmen have now reported orally to the Corporation, and all have submitted written reports. These reports to the Corporation are important to the successful operation of the Committees, and they provide a broadened forum in which to consider the plans and progress of each department. They are invaluable to the functioning of trusteeship at 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 are experimenting with office automation to deal with increased Committee activity as an alternative to adding a third support staff member, due to budgetary considerations. In addition, a seven-year search for volunteer staff assistance with Visiting Committee arrangements has not been successful, although a few volunteers have assisted with arrangements for dinner meetings from time to time. Accordingly, the search for a volunteer has been abandoned, and reliance on word processing is being tried to free up staff time for higher administrative functions. In this interval, the support staff and the writer are sharing the overload.

An interesting development is continuing 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 need of specific centers. The advisory bodies will report to the Dean or the Vice President and provide advice to the research program director. At the same time, a number of Corporation members chair or 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, MIT Sea Grant Program, Laboratory for Manufacturing and Productivity, Center for Transportation Studies, Center for Materials Processing, Center for Advanced Engineering Study, Center for Policy Alternatives, and Plasma Fusion Center; and these are similar in nature to the Joint Center for Urban Studies Visiting Committee, which has served the Joint Center so well over the years. The Office of the Secretary of the Institute has encouraged the directors of these laboratories who have sought advice 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. The Membership Committee of the Corporation has tried to take account of Corporation member participation in these advisory boards in planning Visiting Committee assignments during the past two years.

Once again, I wish to thank Dorothy G. 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. I am deeply indebted to Iris E. Lazarus for her remarkable performance in handling the quarterly meetings of the Corporation and related affairs. Glancing back at the terrain covered this past year, I am frankly not certain how we traversed it all, but I know with certitude that one person made it possible. Mrs. Lazarus' cheerful willingness to tackle any assignment and her understanding of the needs of Corporation members have made her an invaluable asset to the Institute.

There is one individual who once again 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, at home and abroad, has been aided in the conduct of our official duties by MIT's first lady, Priscilla K. Gray. We all owe her a growing debt for the selfless manner in which she has welcomed and contributed to every program and person at the Institute. In a time of return to many conventions and traditions among students, the presence of her radiating influence in the President's House is a blessing on this institution.

Elizabeth J. Whittaker, Administrative Assistant to the Chairman, was named to a new administrative post of Assistant Secretary of the Corporation in June. Miss Whittaker, a 1951 graduate of Wellesley College, will continue to report to the Chairman and she will be available to assist the Secretary of the Corporation from time to time, in areas specified by the Secretary. All of us who have had the privilege of working with her for nearly 20 years congratulate Miss Whittaker on this richly deserved recognition.

This report closes on a dedicatory note. The Corporation has now been chaired since 1971 by Howard W. Johnson, who earlier served for five years as President of the Institute. On June 1, the Chairman announced his intention to relinquish the responsibilities of the chairmanship on June 30, 1983, upon the completion of his twelfth year in the post. He advised the Corporation that he plans to remain at the Institute in his permanent faculty appointment, available to help when needed or called upon by the Corporation. As Special Faculty Professor, Dr. Johnson will devote his efforts to writing and lecturing. President Gray, in acknowledgement of the Chairman's announcement, named an ad hoc committee, chaired by Carl M. Mueller and including Mr. MacDonald and Emily V. Wade, to recommend a successor.

One of MIT's hallmarks is its ability to move gracefully from one period to the next under new leaders, seemingly without missing a beat in its corporate life. It is a measure of MIT's basic quality and coherence that changeover becomes an opportunity for rededication to the Institute's basic mission. Yet, the departure of a superstar takes its inevitable toll on teammates who have been privileged to play alongside, regardless how confident they are in the team's winning ways. Howard W. Johnson has been a winner for MIT. He has known and practiced from the start the happy addiction which Vannevar Bush so aptly called the Institute's habit of success.

VINCENT A. FULMER

Alumni Association

The Alumni Association continues to grow in response to the needs of alumni and the Institute. The alumni staged two major regional conferences, one in Seattle, Washington, and the other in Rochester, New York. Another event of note was a reception in New York City honoring President Paul E. Gray, Class of 1954, and first lady of MIT Priscilla Gray, honorary member of the Alumni Association. A total of 550 guests were present at this memorable evening. Our involvement with students and younger alumni continues. New initiatives were begun with departments to reach out to their alumni. Of particular note were efforts by the Department of Chemistry and its alumni and the joint sponsorship with the Sloan School of Management of a meeting of Sloan graduate alumni. A special word of thanks goes to Angus N. MacDonald, Class of 1946, president of the Alumni Association, and to his wife Monaise who added their counsel and presence to our staff efforts.

The Alumni Fund again broke records in total numbers of donors, number of donors over $100, and total dollars contributed. As always, these were the results of efforts of volunteers led by Joe F. Moore, Class of 1952, chairman of the Alumni Fund Board, and record numbers of students and alumni supported by staff. Most notable of all was a significant growth (over 15 percent) in contributions below $5,000 indicating that the idea of increasing or upgrading one's giving has taken hold among alumni.

During the year four staff members resigned and three were hired. Richard A. Knight, Class of 1947, secretary of the Alumni Association, resigned to resume an association with Heath Corporation of Milwaukee. Ronald A. Stone, Class of 1959, director of operations, resigned to become associate director of development at the Children's Hospital Medical Center. We were fortunate in attracting Shirley M. Picardi, Ph.D., Class of 1976, to become secretary of the Association. Dr. Picardi was formerly associated with MIT's Office of Resource Development. Work progressed in the Long-Range Planning Commission, and a final report in draft form was presented to the Alumni Association Board of Directors in June 1982.

Clubs were revitalized in London and restarted in Venezuela through the collaborative efforts of the Resource Development Office and the Industrial Liaison Program. Our work continues to support the aims of MIT by promoting the interest of alumni in each other and in MIT. To that end the staff of the Alumni Association owes a great debt to the more than 5,000 active volunteers who give so willingly of their time and energy to the benefit of MIT.

Alumni Relations

The annual Alumni Officers Conference was held in Cambridge on September 25 and 26, 1981, with approximately 450 alumni in attendance. Workshops on the Alumni Fund, Alumni Relations, and the Educational Council were followed by a reception and banquet at which Dr. Gray was the keynote speaker. The Alumni Association Business Meeting was followed by a talk by Professor Robert W. Mann, director, District Board of Directors, Class of 1950, on the work of the Eric P. and Evelyn E. Newman Laboratory for Biomechanics and Human Rehabilitation which he directs, and a discussion by Professor Ernest Cravalho on the new Whitaker College of Health Sciences. An awards luncheon was followed by an afternoon symposium on biology and bioengineering. The day ended with a tour of the new building for the Whitaker College of Health Sciences, Technology, and Management and a reception at the President's house.

Dr. Francis E. Low opened the Alumni Council series on October 26, 1981, before the largest audience of the year. Five other sessions followed, with an average attendance of 144.

Students continued to show an interest in alumni activities and to view the Association as a resource. The Alumni Host Family Program matched 125 incoming freshmen and transfer students

with alumni/ae residing in the Boston area. Trailblazing, a career symposium for undergraduates which featured 20 alumni in eight different career areas, was held on February 6 with an attendance of 84 students. Dr. and Mrs. Gray hosted 10 dinners and brunches for seniors at the President's house during February 1982. These were attended by 531 students (43 percent of the graduating class). Each meal featured a brief presentation about the Association's organization and activities, and alumni described their professional work and history of service on behalf of MIT. Students described their plans for the future, and good times were had by all.

The Black Alumni of MIT (BAMIT), in conjunction with the Office of Dean for Student Affairs, sponsored the ninth annual "Black Students Conference on Science and Technology" on October 16 and 17, 1981. Attendance was approximately 350. BAMIT also sponsored their annual welcoming reception for incoming minority students on September 19, 1981, and their exit reception for graduating minority students and guests on May 30, 1982.

The Association of MIT Alumnae (AMITA), in conjunction with the Boston Section of Society of Women Engineers, sponsored a conference on career growth and redirection entitled "Navigating Change" on April 3, 1982, at MIT. Attendance was approximately 150. Technology Day on June 11 focused on the topic "Home Information Systems." Attendance at the symposium was 1,100, with a turnout of 2,000 at the pre-Technology Day festivity, "Tech Night at the Pops," held on June 10 at Symphony Hall. Thirteen quinquennial reunions, held between the dates of June 9 and June 13, brought a total of 900 alumni and guests to campus.

In the regional area, the five regional directors, the president of the Alumni Association, as well as senior Association and Institute staff, traveled extensively on behalf of the Institute. Regional events especially worthy of note include: the "Technology/Northwest Conference" held in Seattle on January 23, 1982, and sponsored by the MIT Club of Puget Sound attracted an audience of about 300 people and featured Dr. Gray; the Mexican Fiesta held March 2-7 in Merida attracted approximately 110 alumni and guests; the "Technology/Rochester Symposium" held in Rochester on March 13 and sponsored by the MIT Club of Rochester attracted an audience of about 150 people and featured Dr. Gray and Dean Gerald L. Wilson, Class of 1961; and a reception attended by 550 alumni and friends to welcome Dr. and Mrs. Gray to New York was held on March 18 at the New York City Public Library. This event was sponsored by the MIT Alumni Center of New York and the MIT Clubs of Fairfield, Hudson Valley, Long Island, northern New Jersey, and Westchester. It was followed the next evening by a dinner meeting of the MIT Club of Princeton, held at E.R. Squibb Headquarters in Lawrenceville, New Jersey, and attended by about 150 people; a meeting of the MIT Club of Maryland held on March 28 at the National Aquarium was attended by 517 people -- a record for that area; and the MIT Enterprise Forum held meetings approximately monthly, with average attendance having increased to 150-250. Other Enterprise Forums have started on a smaller scale in New York City and in the Washington, DC/Baltimore area, and one is being started in northern California; and finally, the Boston Seminar Series, with 128 participants, was composed of six sessions on the topic of "Risk: Global and Local." The Seminar Series is being "exported" to the Washington, DC, area. We are especially grateful to Dr. and Mrs. Gray for their key roles in so many of these regional events, as well as to Angus N. MacDonald, Class of 1946 and Alumni Association president, for his presence at several important events.

The Committee on Nominations for Corporation Visiting Committees recommended to the Corporation that 20 members whose terms had expired be ended, that 40 terms be extended, and that 29 new alumni members be appointed.

The Board of Directors appointed 24 new alumni members and seven chairmen to serve on the seven national boards and committees of the Association. The Board also approved the following recommendations of the Awards Committee:

Bronze Beaver Awards: Leo M. Beckwith, Class of 1935; C. George Dandrow, Class of 1922; Joseph G. Gavin, Jr., Class of 1941; Richard A. Knight, Class of 1947; John L. Riegel, Class of 1919; Antonio H. Rodriguez, Class of 1921; Guy J. Viellet, S.M., Class of 1950; and Frank S. Wyle, Class of 1941.

The Harold E. Lobdell, Class of 1917, Distinguished Service Awards: Bradford Bates, Class of 1959; S. Martin Billet, Class of 1948; Roger Borovoy, Class of 1956; Gates Burrows, Class of 1925; Margaret T. Coleman, Class of 1950; N. Bruce Duffett, Class of 1940; Susan L. Kannenberg, Class of 1961; Loughrey R. Kuhn, Class of 1967; G. Edward Nealand, Class of 1932; Robert P. Pinckney, Class of 1952; Philip Schwartz, Class of 1923; and Peter Sexton, Class of 1965.

The George B. Morgan, Class of 1920, Awards: Dempster Christenson, Class of 1938; Maxwell Coutts, S.M., Class of 1939; Stanley Martin, Class of 1950; Harold Radcliffe, Class of 1941; John Walch, Class of 1948; and Walter S. Wojtczak, Class of 1937.

Presidential Citations: The AMITA Career Seminars; the AMITA High School Visiting Program; the Class of 1942, 40th Reunion Gift Committee; the MIT Club of Milan Technology Symposium; the MIT Club of Puget Sound Technology/Northwest Conference; and the MIT Luncheon Club of Washington, DC.

Honorary Memberships in the MIT Alumni Association: Professor Roy Lamson and Warren A. Seamans.

The following alumni were elected by national ballot to serve three-year terms on the National Selection Committee: Susan L. Kannenberg, Class of 1961, District One; Bernard H. Nelson, Class of 1935, District Two; and Leonard F. Newton, Class of 1949, District Four.

The Association supports the Corporation Screening Committee ballot process which elected Heidi R. Wyle, S.M., Class of 1980, to serve a five-year term on the Corporation. The National Selection Committee met in November 1981, and made the following selections:
Terms on the Corporation: David E. Kosowsky, Sc.D., Class of 1955 (five-year term); Angus N. MacDonald, Class of 1946 (five-year term); E. Kirkbride Miller, Jr., Class of 1941 (five-year term); and Frank Wyle, Class of 1941 (three-year term).
President of the Association: Denman K. McNear, Class of 1948.
Vice Presidents of the Association: Thomas H. Farquhar, Class of 1960; and Robert W. Mann, Class of 1950.
Directors of the Association: Lorna J. Giles, Class of 1975; Leslie C. Hruby, S.M., Class of 1973; Louis F. Kreek, Jr., Class of 1948; and Alfred Wu, Class of 1940.

Alumni Fund

Entering its fifth decade of operation, the Alumni Fund, under the chairmanship of Joe F. Moore, Class of 1952, set new records of alumni support of the Institute. A total of $7,715,000 was received in gifts from 25,842 alumni, resulting in a participation of 42 percent. Thus, for the fourth consecutive year, both the number of alumni contributors and the dollars received in the Alumni Fund exceeded the previous year's totals. Moreover, the $7.7 million counted in the Alumni Fund marked the eighth straight year of increased dollars in the Alumni Fund. Other highlights of achievement included the $1 million received in 4,300 matching gifts from corporations, the 6,600 gifts (25 percent) of $100 or more to the Fund and the 1,969 first-time gifts to the Fund. These results were made possible by the efforts of nearly 2,000 alumni and student volunteers who made solicitation visits and calls on behalf of the Alumni Fund.

During the past year, most Fund programs including Direct Mail, Personal Solicitation (PS), Young Alumni, Major Reunion Gift, Senior Gift, and Matching Gift were conducted in the format established in recent years. The fact that results continue to exceed goals gives evidence of the soundness of this program strategy.

Telethons continued to be an increasingly important component of the Alumni Fund. A total of five telethons was held on campus with an additional 22 in cities across the United States and Canada. The 1,157 volunteer callers, a 41 percent increase over fiscal year 1981, contacted more than 16,000 alumni and received $502,000 in pledges from nearly 11,000 individuals. All of these totals far exceeded the results of prior years. Included in the telethon program was an effort aimed specifically at increasing support from alumni with a graduate degree from MIT. This new venture proved successful with 37 callers obtaining 582 pledges.

The PS program continued to be a key solicitation effort in the fall. Conducted in eight metropolitan locales, some 100 specially trained alumni solicitors made personal visits to more than 400 prospects, seeking upgraded gifts to MIT. Of those alumni contacted, 93 percent made a pledge to the Fund and, true to the program objective, nearly two-thirds of the gifts represented an increased level of support for MIT.

Young alumni support of MIT continued to grow. A total of 877 alumni of the five most recently graduated classes made a first-time gift to the Fund. Moreover, the Class of 1977 set a precedent

by establishing a fifth reunion gift amounting to more than $15,000. Through that effort, more than 70 percent of the class have made at least one gift to the Alumni Fund since graduation -- a level of involvement that took 50 percent less time to achieve than has been the case with other young classes in recent years. As further evidence of young alumni support, 368 members of the Class of 1982 contributed $4,100 as a senior gift to MIT which was matched by the 50th reunion Class of 1932. Additional pledges amounting to $17,300 were made by 266 members of the class. Both totals represented new records for the revived senior gift program.

Major reunion class gifts of $4,916,000 were reported on Technology Day 1982. The 50th reunion Class of 1932 amassed a total gift of $1,375,000 with 64 percent of the class participating in the effort. In addition, pledges of future gifts from members of the class totaled $820,000. The Class of 1942, celebrating its 40th reunion, gave the largest of these gifts -- $1,876,000 from 61 percent of the class. Approximately $1.5 million of this gift has been designated by the class to establish the Class of 1942 professorship and the Class of 1942 career development professorship. The gift of the 25th reunion Class of 1957 was $1,665,000 -- the largest 25th reunion gift in MIT's history. Included in the total was $325,000 to establish the Class of 1957 career development professorship. During the year, there were 13 luncheons held in major US cities for alumni approaching their 40th and 50th reunions. These meetings inform alumni of the many methods that can be used to make a substantial gift to MIT, including life income plans.

In its second year of existence, the Alumni Fund's donor recognition program, entitled the "Great Dome Associates," enjoyed great success. This program, which recognizes alumni who make annual gifts to MIT of $250 or more, extended membership to 2,312 alumni, a 28 percent increase in participation over 1981 and 9 percent of the total alumni contributors to the Fund.

The Alumni Fund received special recognition this year in the form of a $4,000 grant from the US Steel Foundation for winning the Grand Award in the sustained performance category of the Alumni Giving competition, sponsored annually by the Council for Advancement and Support of Education (CASE) and the US Steel Foundation. By definition, "sustained performance" encompassed a three-year period (1979-1981) of increased dollars and contributors to the Alumni Fund. The Alumni Fund was selected as Grand Award winner over 100 finalists in the competition.

Finally, the Alumni Fund had one staff change this year. Brenda L. Hambleton, Class of 1979, left the Alumni Association to accept a position with MIT's Admissions Office and was replaced as telethon and senior gift coordinator by Jeffrey R. Solof, Class of 1981. In summary, the Alumni Fund achieved extraordinary success in this, its 41st year.

Technology Review

In an environment of intense competition, *Technology Review* made modest gains in 1981-82. Increasing alumni involvement with MIT brought our alumni circulation to 37,000 by the end of the year; paid circulation stood at 38,000; and print orders for the last few issues of the year exceeded 95,000.

The last figure exposed the year's principal frustration: the *Review* proceeded with its plans for increased promotional efforts, chiefly through direct mail, with very good results in terms of the number of new subscribers accepting trial subscriptions. But, like other magazines in the field, we found that unexpectedly large numbers of these trial subscribers failed to accept the magazine after receiving one or two copies. A modest research effort failed to identify any single reason; we attribute this low "pay rate" to the competitive environment and poor economic conditions, and take comfort in the fact that *Technology: The Magazine of Applied Science* suspended publication because its low "pay rate" put its circulation guarantees out of reach.

Advertising and circulation income exceeded projections, but the cost of providing trial subscriptions to many who turned out to be non-subscribers along with sharp increases in postage rates forced costs to exceed projections. The renewal rate remained at over 55 percent.

Seeking to respond to the low "pay rate," the editors have sought throughout the year to enliven the content and graphics of the magazine. There have been more shorter features than in previous recent volumes and a number of notable contributions from professional writers, scientists, engineers, and policymakers. Class secretaries continued to provide the usual

complete and timely reports of their classmates' activities, and the MIT news pages reported all major Institute developments.

Leonard A. Phillips left *Technology Review* early in 1982 to accept an excellent editorial post elsewhere, and as the year ended Jonathan Schlefer joined us as senior editor to take over Mr. Phillips' assignment as editor/manager of the "Trends" section. Nancy Cahners Pokross, who has served as the *Review* 's design director while a member of the Design Services, became a full-time member of the *Review* staff at the end of the year.

Two meetings concerning the *Review* are worth special mention: First, an ad hoc committee called together by the Alumni Association's Long-Range Planning Commission reviewed the *Review*'s program and its relationship with the Alumni Association. Its chairman, Edward T. Thompson, Class of 1949, later reported to the Long-Range Planning Commission the group's judgment that no changes in program or administration should be made. Second, the annual meeting of the *Review*'s Advisory Board (Claude W. Brenner, Class of 1947, chairman) was the occasion for a thorough discussion of both business and editorial operations. Following the meeting, Mr. Brenner told the Board of Directors that he hoped for a closer relationship for himself and other members of the Board with the editorial activities during 1982-83.

Alumni Records and Administration

Implementation of the Alumni/Gifts database management system was marked in 1981-82 by completion of conversion to the interactive mode of operation. Previously, interactive terminals were used for querying the database. Starting in the summer of 1981, they were also used for entering data. This required changes in daily operations, training in new procedures, and reporting to the development team as problems were encountered. With the addition to the database of corporate gift information maintained by the Treasurer's Office, a unified source of Alumni/Gifts information became a reality. At year end the master file of the database contained a total of 100,105 records. Of these, 75,132 living alumni were recorded, and 5,212 known deceased since 1972 were recorded. Corporations, foundations, widows, honorary alumni, and other donors to MIT comprised the balance of 19,761 records.

In the fall of 1981, the shift from the development phase to the production phase of implementation of the system was accelerated. Parallel operation of the old batch-oriented system ceased. Full reliance on the interactive mode was under way. Several changes occurred in the Information Processing Services/Administrative Information Systems team supporting the implementation of the system, thus confirming the shift.

The principal focus during the second half of the year was on pulling together all remaining developmental tasks. This involved working with the old and new area teams as they continued debugging the installed system, programmed additional reports, and documented the installed system.

The planned reorganization of the Records/Administration unit was implemented on July 1, 1981. The positions of records maintenance manager and information retrieval manager were filled by internal promotions. At mid-year the latter position was vacated by leave of absence. The position of database manager was vacated by resignation and subsequently was filled from within MIT by John M. Bidwell, Class of 1956.

WILLIAM J. HECHT