OFFICE OF THE
DEAN OF SCIENCE
OCT 17 1972
to
re

MASSACHUSETTS INSTITUTE OF TECHNOLOGY BULLETIN

REPORT
OF THE
PRESIDENT
1971

MASSACHUSETTS INSTITUTE OF TECHNOLOGY BULLETIN

REPORT
OF THE
PRESIDENT
FOR THE ACADEMIC YEAR
1970–1971

MASSACHUSETTS INSTITUTE OF TECHNOLOGY BULLETIN
VOLUME 107, NUMBER 2, SEPTEMBER, 1972

Published by the
Massachusetts Institute of Technology
77 Massachusetts Avenue, Cambridge, Massachusetts,
five times yearly in October, November, March, June, and September
Second class postage paid at Boston, Massachusetts.

Issues of the Bulletin include
REPORT OF THE TREASURER
REPORT OF THE PRESIDENT
SUMMER SESSION CATALOGUE
PUBLICATIONS AND THESES
and
GENERAL CATALOGUE

Send undeliverable copies and changes of address to
Room 5-133 Massachusetts Institute of Technology
Cambridge, Massachusetts 02139.

THE CORPORATION

Honorary Chairman: James R. Killian, Jr.
Chairman: Howard W. Johnson
President: Jerome B. Wiesner
Chancellor: Paul E. Gray
Vice President and Treasurer: Joseph J. Snyder
Secretary: John J. Wilson

LIFE MEMBERS

Bradley Dewey, Vannevar Bush, James M. Barker, Thomas C. Desmond, Marshall B. Dalton, Donald F. Carpenter, Thomas D. Cabot, Crawford H. Greenewalt, Lloyd D. Brace, William A. Coolidge, Robert C. Sprague, Charles A. Thomas, David A. Shepard, George J. Leness, Edward J. Hanley, Cecil H. Green, John J. Wilson, Gilbert M. Roddy, James B. Fisk, George P. Gardner, Jr., Robert C. Gunness, Russell DeYoung, William Webster, William B. Murphy, Laurance S. Rockefeller, Uncas A. Whitaker, Julius A. Stratton, Luis A. Ferré, Semon E. Knudsen, Robert B. Semple, Irénée du Pont, Jr., Eugene McDermott, James R. Killian, Jr.

MEMBERS

Albert H. Bowker, George P. Edmonds, Ralph F. Gow, Donald A. Holden, H. I. Romnes, William E. Hartmann, Frank R. Milliken, Henry E. Singleton, Gregory Smith, Thorton A. Wilson, James A. Champy, Elisha Gray II, William R. Hawthorne, Jerome H. Holland, Breene M. Kerr, Carl M. Mueller, Harold E. Thayer, Jeptha H. Wade, Virgilio Barco, William S. Brewster, Ralph M. Davison, John C. Haas, Philip H. Peters, Mary F. Wagley, D. Reid Weedon, Jr., Paul M. Cook, William S. Edgerly, J. Kenneth Jamieson, Kenneth H. Olsen, George W. Thorn.

REPRESENTATIVES FROM RECENT CLASSES

Laurence Storch, James A. Hester, Christina H. Jansen, Michael V. Sawyer, Pamela T. Whitman.

PRESIDENT OF THE ALUMNI ASSOCIATION

Paul V. Keyser

REPRESENTATIVES OF THE COMMONWEALTH

Governor: His Excellency, Francis W. Sargent
Chief Justice of the Supreme Judicial Court: Honorable G. Joseph Tauro
Commissioner of Education: Neil V. Sullivan

LIFE MEMBERS, EMERITI

Alfred L. Loomis, Harlow Shapley, Walter J. Beadle, Duncan R. Linsley, Irving W. Wilson, Ralph Lowell, Gwilym A. Price, James H. Doolittle, Robert A. Lovett, Horace W. McCurdy.

CONTENTS

VICE PRESIDENT AND SECRETARY

OTHER OFFICES

PRESIDENT

In presenting my annual report for 1970-71, I am conscious that it is the last in the series that I will have submitted as President of the Institute.

At the outset it is important to emphasize two enduring propositions: that ours is an institute based on education in science with a primary focus on enlarging the horizons of science; and, second, that we are fundamentally concerned with the development of technology and with its applications to society. Both parts of that statement, *the cultivation of science and technology* and the sharpening concerns for their *application to society,* are critical parts of our franchise. It is worth repeating that statement at a time when a broad public concern has arisen about science and its applications and when there is new public concern about the support of higher education generally. The most important reflection growing out of this year is that we at M.I.T., in our own way, and in a way wholly consistent with our purpose, must understand these concerns, must meet them openly, and must seek to answer them. Throughout its history, M.I.T. has shown an exceptional ability to combine constancy of principle and continuity of direction with a willingness to change our educational approach within this framework. We will need this ability now and in the years ahead.

It was to this fundamental of the M.I.T. education that I spoke five years ago:

> As the Institute founded by William Barton Rogers proceeds in its second century, we call for a renewal of our historic plan. The elements of this plan draw from the basic fiber, the very character of this institution: our power to act, our foundation in science, our commitment to research, our determination to build the humanities and the arts, our emphasis on the importance of the environment and, above all, our expectations for the performance of our students. These basic propositions make M.I.T. a university that never looks back as a conserver of the past but always forward as a maker of the future.

These last five years have seen us persist on these lines.

My reports in these years have sought to review the significant events of the year, both our accomplishments and our shortcomings. I have thought it was important, also, to stress the need for asking the right questions of the events around us, to maintain a capacity for thinking about the future in spite of the pressure of current events, and to reflect deeply on the alternatives before us. This report follows that outline.

First, on the year itself. It was a good year for M.I.T. Much was accomplished that gives our future a better chance. I do not mean it was a quiet one. There was dynamic effort and interaction. But the Institute was not subjected to the constant threat of confrontation near the surface which had been present in other years, and there was a sense of healthy change and vitality that was good for all of us. Two questions that I raised in last year's report, the danger of politicizing these institutions and the problems of maintaining an internal and independent discipline system, seemed to have lost their immediacy as pernicious problems. A great deal of reevaluation of our educational process and a stimulation stemming from many sources but principally due to the excellent effort of the M.I.T. Commission produced much useful debate and the outline of new directions.

The record of any university and certainly of our Institute is best expressed in the growth and learning of the people associated with it. In the best of times and in the worst of times, individual students, faculty members, researchers, and employees find their way to learning and performance. One expression of individual attainment is the conferral by M.I.T. of 974 undergraduate degrees and 1,283 graduate degrees, including 400 doctorates, a total of 2,257 in the last year. Accomplishment is also expressed in the awarding to faculty and staff members of major honors including the Nobel Prize and many other distinguished awards, as well as less visible but equally significant forms of recognition. I suppose, too, that accomplishment is noted by the quality of our graduate programs. Once again, the American Council on Education has rated the Institute among the top half-dozen universities of the nation and first in our own category.

New developments in curriculum, about which I will say more later, made excellent headway. Curriculum changes were taking place as the M.I.T. Commission continued the discussion of its first report. The stimulation produced by that report, the formation of a special task force on education, and the continuing experimental efforts by several departments, notably in the School of Science, promise major productive and student-centered programs for the near future. We saw more effort in the public policy area and in various interdisiplinary efforts at both

the graduate and undergraduate levels. We saw the effective beginnings of several new laboratory efforts. The most visible change perhaps was the successful inauguration of a one-month independent activity and study period between the fall and spring terms. The experience surpassed expectations. Let us see if there is equal enthusiasm in the next few years. One new program deserving special note was the planning and building of the Community Fellows Program for leaders of community organizations, to begin in the fall of 1971.

In the continuing struggle to maintain financial support for research at M.I.T., we have largely held our own. There were small increases in the level of research on the campus as a whole and in the off-campus laboratories, but inflation made such levels less productive. Support for efforts in new fields in environment and in health sciences and for maintaining important basic areas was difficult to obtain.

The many laboratories at M.I.T. are engaged, consequently, in a struggle of funding good ideas in a spare Federal climate. In an important specific case, I have reported on the Draper Laboratory in the past years, and its progress is described in the report of its Chairman and President. We continue to develop its disengagement from the Institute, conscious of our requirement to keep the Laboratory sound in the process and slowed, I suppose, by the general downtrend in activity in the area of its greatest expertise. We persist, with the leadership of an outstanding board, in our efforts.

A steady erosion of support in some key areas was a worrisome concern. For example, support for graduate students in critical fields across the country is waning. The number of Federal graduate fellowships is about 40 per cent less than it was four years ago, and that number is further declining. While M.I.T. is faring somewhat better than most, we face a serious crisis in the support of able young people who wish to pursue science and engineering at the graduate level.

Other areas are more positive. A review of last year shows that our effort in enrollment of minority students, both graduate and undergraduate, and in minority staff employment continued to make progress. The number of women students has increased by about 10 per cent to over 600. In September, 1970, 91 women entered M.I.T. as members of the freshman class; this year that number will exceed 120, the largest on record.

The year was marked by the opening of the Frank S. MacGregor House, a dormitory residence housing 324 students, and the completion in 1971 of the remodeling of Burton-Conner, housing 344 students. Construction on a third student residence, Westgate II, which will house approximately 400 graduate students, was begun. Among academic

buildings, the Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics was dedicated. Work on the George R. Wallace, Jr., Astrophysical Observatory was essentially completed, and plans for the formal dedication are tentatively scheduled for this fall. Work was begun on the electrical engineering and electronics buildings, M.I.T.'s largest single building project since the move to Cambridge. On the building front beyond our campus, a major phase of M.I.T.'s housing program in Cambridge, 684 units for the elderly, was approved by the Department of Housing and Urban Development and is the nation's largest project under the Turnkey Program.

On the fiscal side the Institute finished the year on a break-even basis, once again without incursion on endowment funds. We did so in the face of major inflation and cost pressures, both regular and unexpected in nature. This result was achieved by continued cost-cutting effort; by increased revenues from tuition and endowment income; by near-record gifts, grants, and bequests; by the relentless draw on unrestricted current balances; and by deferment of some needed programs. When one considers the demands during the year on new funds for substantial student aid, the new building construction, and a substantial addition to the endowment capital of the Institute, this financial balancing act is noteworthy. The fund raising efforts of the Institute resulted in a total of 39.6 million dollars in gifts, grants, and bequests, barely exceeded in only one other year in the Institute's history. Included in this total were the gifts of the largest number of contributing alumni on record. The longer term outlook is not as bright, but it is satisfying to report this result in the atmosphere of general gloom on the collegiate financial scene.

Plans were completed during the year to elect representatives of recent classes to the Corporation. In the spring five young trustees were recommended for election to the Corporation, to take office in the coming year.

Finally, a new chapter in the Institute's history was begun with the election of Jerome B. Wiesner as President and the concurrent election of Paul E. Gray as Chancellor, a new version of a time-honored office at M.I.T. designed to add further depth to the leadership of the Institute. Both appointments became effective on July 1, 1971.

The year ended with a Commencement full of hope, I thought, and full of challenges rightly placed before this institution.

And so another year goes into the record. The events are recorded in detail in the reports of the Schools, departments, and offices of the

Institute. What does one discern from these diverse events? Are the pieces reported here isolated parts of the experience of the human beings that make up the long line of history that is M.I.T.? Some undoubtedly are, but others add to a pattern, often begun long before our time and continuing as part of a gradual evolution and probably revolution of the Institute. Let me cite some of the more important patterns as they appear to me.

TEACHING

It is instructive to chart the change in the undergraduate pattern of education from one of complete prescription to one of a substantial requirement for individual selection and individual responsibility. Let us take, as an example, ten years ago. In the fall of 1961, 900 freshmen enrolled in a uniform program consisting of a two-term sequence in general chemistry, physics, calculus, introductory humanities, and one elective subject each term chosen from a list of 16. Each freshman registered for the five subjects. There were very few exceptions.

At the writing of this report in September, 1971, 1,000 freshmen assembled in Kresge Auditorium to hear faculty and deans describe five options in chemistry (including biology), six options in physics, six options in calculus, and five options in the freshman humanities. In addition, freshmen learned they could take undergraduate seminars, participate in the Undergraduate Research Opportunities Program, and choose from a list of some 200 elective subjects offered by virtually all of the Institute's 24 departments. Furthermore, a number of freshmen now have an opportunity to spend the year in one of three experimental programs, known as the Experimental Study Group, the Unified Science Study Program, or the Concourse Program.

M.I.T. has always asserted that this is a place where mature students decide what they want to do and have an opportunity to do it. In the past ten years we have come a long way toward achieving this goal in the first year of our education. It has been the result of hard work and imaginative thinking on the part of many generations of teachers, undergraduates, and administrators who, in the M.I.T. tradition, have not been satisfied with a successful past but who have sought each year new standards of accomplishment and flexibility. In every department there are now programs offering diverse alternatives for the student. There is effective cross-registration with other institutions, notably Wellesley College.

The same can be said for other levels of education. We see signs that the opportunity to participate in the choice of one's own program produced a greater sense of responsibility and most likely some gain in standards of performance.

As a direction, then, I see increased emphasis on individual responsibility accompanied by multiple paths to high performance. I believe the result will contribute to even higher standards of performance in real life — in choice, in risk, in achievement.

FIELDS OF STUDY

A second direction is noted by the development and growth of new fields of study at the Institute. It is tempting to cite too quickly the fields of worth and deep intellect that characterize the vital interest of all of us today — the health sciences, the urban field, the studies of environment, transportation, and other systems of management, and engineering. But we should not overlook the fields in which the Institute has labored for years and which take on new edge and new challenge: every field of more traditional application of the civil, mechanical, chemical, electrical, and ocean engineering, as well as new emphasis in other important applied fields. The new fields include areas which have historic roots in the curriculum. Our new Department of Philosophy is one example. Our program of joint degrees with the Woods Hole Oceanographic Institution is another. There is a growing interest and, I hope, competence in problems of public policy associated with the application of technology. A study of the General Catalogue demonstrates the difference. A study of recent graduate student theses is even more revealing.

There is no decay of interest in fields of long investment and importance, but the direction is, as I once said, toward areas of greater human significance.

THE NATURE OF THE M.I.T. POPULATION

There are other areas where direction can be plotted. In recent years the recognition of the full contribution of women within the staff and in the student body has been better appreciated. From the time of Ellen Swallow Richards, a hundred years ago, the place of women has been secure, but increasing numbers more nearly reflect the growing recognition of women's potential and accomplishment. The same can be said of the black students and staff. The contribution made to education and to understanding among different people is great and growing. Let no one doubt the meaning of this growth. An earlier recognition, that of M.I.T. as an international as well as an intensely national institute, is seen from the records of the registrar. I do not know of an institution of the first rank which has as large a proportion of students and staff from outside the country. The relationship of this fact to the ultimate search for the whole brotherhood of man is worth noting, especially in this time of increasing international tension.

THE WORKING ENVIRONMENT

I note another direction. It relates to the increasing concern for our surroundings both on the campus and in the cities in which we live. I do not refer solely to the massive addition of new buildings on the campus, important as these additions have been. Rather I mean the way in which the Institute is a place for trees, for greenery, for color, and for beauty of design and interest. It shows from Massachusetts Avenue to the unexpected parks that dot the campus. I am also glad to note the way in which we have participated and sought to participate in the improvement of Cambridge and Boston. Both factors respond to real need. Both advance the spirit.

CONTINUITY

If these areas represent innovation where we believe that change helps to achieve a finer result, there are fundamentals of the Institute that have not changed, where the direction remains steady and where we derive satisfaction from some beliefs that do not change with the times. I have already noted some of these. Paramount is our base in science. We continue to believe that the pure scholarship of science is important for its own sake, as the extension of man's understanding of nature. Teaching and research into the fields of science are our preoccupation, and I see little inclination to shift this commitment at M.I.T. Beyond the work of the individual scientist and his student, I also see a continuing lively interest in larger programs, mobilizing the efforts of many in laboratories and in various sponsored programs. This larger effort has constantly demonstrated itself as a method of education, as well as a way to find answers to significant problems. The record of the work of our faculty and staff, ready to take on new and ambitious assignments, continues to be outstanding.

STILL BEFORE US

But apart from those directions that show constant evolution and apart from those that are as fixed in M.I.T.'s life as the parts of the compass, there is a third category — those areas of large importance, present and potential, where we are seeking, still, to understand the problem and to find a clear pattern. These are still unsolved problems of transcending importance to M.I.T. I would cite our need to understand the full power of the humanities and liberal studies in our curriculum and to realize the fruits of our understanding. We know that the study of humanities must be interlocked with the study of science, that there is a unity of liberal education. We know, too, that achievement of this oneness of education is a reality for many of our students. And yet, we are troubled

by the apparent inadequacy of our educational structure to ensure that this integration is fully effective. There seems to be a fault in the face of our structure. It is a problem of immense significance. M.I.T.'s singular strength in both science and humanities should make the Institute a special place for dealing with this issue. But we have not yet found the way.

Another problem that lies before us is to seek a better definition of the role of the Institute in public service. We are proud of our efforts up to the present, and we will surely continue to render a significant contribution to the technological problems of our society. But the paths are more complex in these times, and the integration of service with education poses some quandaries where resolution is not yet clear. Public service and M.I.T. go together. It is a grand tradition, but new definitions of the interface are yet to be found.

There are other problems, now common to higher education in general, that deserve our best attention. There is a pressing demand for patterns of education for adult life, for alumni for example, and for mature professionals in many fields. M.I.T. has some world-famous examples of effective programs: the Sloan Fellowship Program, the Advanced Engineering Program, the SPURS Program for foreign professionals, among others. We have alumni seminars and the special summer programs, but surely the new technology can produce imaginative ways to satisfy the need to learn anew, and we must find them.

There is still under the heading of problems a wholly new specter of underutilization and unemployment for new advanced degree holders in this decade, especially in the areas of physical sciences and engineering. The sources of the problem are complex but rest mainly in the distortions of an on-again, off-again government demand and in the long lead-time for education of a doctoral candidate. Boom or bust is no basis for effectually providing for the scientific development of the nation. I do not agree with the grim predictions of those who see major unemployment in the last half of the decade. The market, as it has in the period of "shortages," adjusts relatively quickly. But there is a problem, and we are concerned.

We share other problems with the world of education. I have spoken in each of my annual reports on the problem of financing M.I.T. We are a special place, and we fare a bit better than many others. But the financial problems ahead for higher education are horrendous. Increasing tuition must continue in the face of rising costs, but I, for one, fear that such a continuation will bear most heavily on the large middle group of our students that fall in the financial range between the very needy and the very affluent. I fear that a steadily rising collegiate budget

could eventually prevent many of them from attending M.I.T. There is a very real need here that has not received adequate attention by anyone in higher education.

We must maximize our efforts at raising private resources. The satisfaction of investment in private education is still there despite the occasional uneasiness for some that accompanies the support of youth. But quality institutions need Federal support in addition, and new forms of that support must be devised if the long-term interests of our society are to be protected. It is almost that simple.

And now I come to the closing of my report on last year. In addition to the election of our new President, the year saw five new appointments as heads of departments in the Institute. Professor Glenn A. Berchtold succeeded Professor John Ross as Head of the Department of Chemistry; Professor Kenneth M. Hoffman succeeded Professor Norman Levinson as Head of the Department of Mathematics; Professor Edward A. Mason succeeded Professor Manson Benedict as Head of the Department of Nuclear Engineering; Professor Eugene B. Skolnikoff succeeded Professor Robert C. Wood as Head of the Department of Political Science; and Professor Richard L. Cartwright became the first Head of the new Department of Philosophy.

In an understandably rapid turnover leading to his election as Chancellor last March, Professor Paul E. Gray was appointed Dean of the School of Engineering last December, succeeding Dean Raymond L. Bisplinghoff, who requested leave of absence to become Deputy Director of the National Science Foundation. In July Professor Alfred A. H. Keil, Head of the Department of Ocean Engineering, succeeded Dean Gray as Dean of Engineering. In another category, Professor Hartley Rogers, Jr., was elected Chairman of the Faculty, succeeding Professor William T. Martin, who served in that post with distinction for two of the most active years on the Institute's record. All of these colleagues deserve our greatest appreciation. We are grateful to them.

Again last year, distinguished members of our faculty reached retirement age, and I would like to note their remarkable service to generations of M.I.T. students. They are Lawrence B. Anderson, Dean of the School of Architecture and Planning; E. Lee Gamble, Professor of Chemistry; Truman S. Gray, Professor of Electrical Engineering; and John T. Nickerson, Professor of Nutrition and Food Science. They have made immense contributions to the quality of M.I.T.

I report too the retirement of James R. Killian, Jr., Chairman of the Corporation, who completes more than 40 years of service to M.I.T.

This distinguished record of service to the Institute, to our country, and to the world of education has few equivalents in our time.

And so I come to the end of this report. I do so with a conscious and studied sense of optimism about M.I.T. and its future. I am aware that the prevailing atmosphere for higher education tends to be gloomy. I do not share it. There is, I know, a foreboding sense of a world trying to move away from technology yet knowing that technology must provide the basis for dealing with our largest problems. M.I.T. has a continuing and positive part — a unique part — to play in the solution of these problems. And as for the gloom, we must remember that the world of higher education has come through a rough and stormy period, unmatched in history. While no one can say that the period is over, the shape of the problems ahead is now better defined. Who can say that the assaults on the university from within or without are over, but they have tended to subside. And, it can be said, we have a certain experience.

Frankly, we should have expected a difficult transitional time. The society of man has a way of correcting extremes of both position and expectation. From a pendulum swing in which many thought the universities could do no wrong, we have come through a time when many thought that the universities could do no right. The truth, of course, lies at neither extreme. Some scars will remain, some for a long time. No institution of note is immune from them. But there is a clearer understanding now that universities are human institutions which should be distinguished by their overriding concerns for learning and for the uncharted frontiers of the mind. Such concerns are bound to produce discomfort, but they also provide the best way yet devised to deal with man's insatiable quest for understanding himself and nature and for sustaining civilization. Those are big enough preoccupations for any human institution. Now it remains for each institution to reexamine its charter — to seek to understand the basis on which it deserves support and then to follow its own course resolutely.

For us at M.I.T. we have had an opportunity to test our foundations. They are firm. In the most placid of times perhaps the best thing that an administration can do is to get out of the way and let the work proceed. These have not been placid times. The record is there to be examined. We have continued on our path of improving our pattern of education, and we have sharpened our old sense of purpose. We are stronger, in a sense, than we were. But we will need every support we can muster in the future, and we must be bold in calling for that support. In a world that is above all a technological one, M.I.T. has too important a calling to be content with less than a preeminent contribution through education, research, and service to the improvement of man's state. With

the leadership of our new President, I have no doubt that we will continue to forge ahead.

And, at the end, how does one adequately speak the appreciation he feels to all in the administration and all of those who are joined in the work of M.I.T. Let me cite them: the Faculty, the members of the Corporation, the staff and employees, the student body, and the alumni. They are a splendid company. There will be many of us, I believe, who will remember these past days and years and will be glad that we were here in this place and at that time.

HOWARD W. JOHNSON

STATISTICS FOR THE YEAR

The following paragraphs report briefly on various aspects of the Institute's activities and operations during 1970–71.

REGISTRATION

In 1970–71 student enrollment was 7,799, a decrease of 225 over the 8,024 enrolled in 1969–70. This total was comprised of 4,120 undergraduate and 3,679 graduate students.

Graduate students who entered M.I.T. last year held degrees from 306 colleges and universities, 179 American and 127 foreign. The foreign student population was 1,358, representing 17 per cent of the total enrolled. The foreign students were citizens of 87 different countries.

Degrees awarded by the Institute in 1970–71 included 955 Bachelor's degrees, 19 Bachelor of Architecture degrees, 770 Master's degrees, 113 Engineer degrees, and 400 Doctoral degrees — a total of 2,257.

The number of women at M.I.T., both graduate and undergraduate, has increased continuously. In 1970–71 there was a total of 604 full-time women students at the Institute, compared with 557 in 1969–70. In September, 1970, 87 women freshmen entered M.I.T. In September, 1969, the number was 73. In 1970–71, 108 degrees were awarded to women, compared with 96 in 1969–70.

STUDENT FINANCIAL AID

During the 1970–71 academic year the student financial aid program was characterized by increases in total awards, in number of individuals assisted, and in loans made and by a decrease in the relative percentage of scholarship funds used.

A total of 2,270 undergraduates who demonstrated the need for assistance (57 per cent of the enrollment) received $2,995,208 in

scholarship aid and $1,510,198 in loans. The total, $4,505,406, represented a 7 per cent decrease in direct aid over last year.

Scholarship assistance was provided by the scholarship endowment in the amount of $1,378,475; by outside gifts for scholarship in the amount of $502,659; in the form of direct grants to needy students totaling $646,224; and by M.I.T.'s own operating funds in the amount of $325,400. The special program of scholarship aid to minority group students represented an additional $142,450 from specially designated funds. An additional 153 students received direct grants from outside agencies, irrespective of need, in the amount of $242,200. Outside scholarship support thus totaled $1,391,083, slightly higher than last year's total.

The undergraduate scholarship endowment was increased by the addition of three new funds. These new funds, together with supplements to others, represent an addition of $400,012 to the scholarship endowment, whose principal now stands at $19,108,514.

Loans totaling $1,510,198 were made to needy undergraduates. Of this amount, $362,684 came from repayments to the Technology Loan Fund; $995,929 from the National Defense Loan Fund; and the remainder from other M.I.T. loan funds. An additional $398,818 was obtained by undergraduates from state-administered Guaranteed Loan Programs and other outside sources.

Graduate students obtained $292,925 from the Graduate Loan Fund established to provide loans at prime commercial interest rate. As a lender under the Guaranteed Loan Program, M.I.T. also made $197,900 in loans to graduate students under this program. The total loaned by M.I.T. to 2,034 graduate and undergraduate students was $2,128,277, a substantial reduction from last year's total.

PLACEMENT

It was a challenging year for the Placement Bureau. The depressed state of the economy sharply curtailed the number of jobs available to graduating students and to alumni seeking new positions, and the Bureau was hard pressed to provide effective help.

The number of firms and government agencies which came recruiting was down by a quarter, from 286 in 1969–70 to 216. The drop followed a significant reduction in recruiting in 1969–70. Many of the firms that came had few jobs to offer. Many that did not come reported that they would be hiring no one.

One response of students was to stay out of the job market. Fewer Bachelor's and doctoral degree candidates made interview appointments. The number of Bachelor's candidates having interviews dropped to 294

FIGURE 1

FINANCIAL AID TO UNDERGRADUATE STUDENTS
FROM ALL SOURCES, 1961-1971

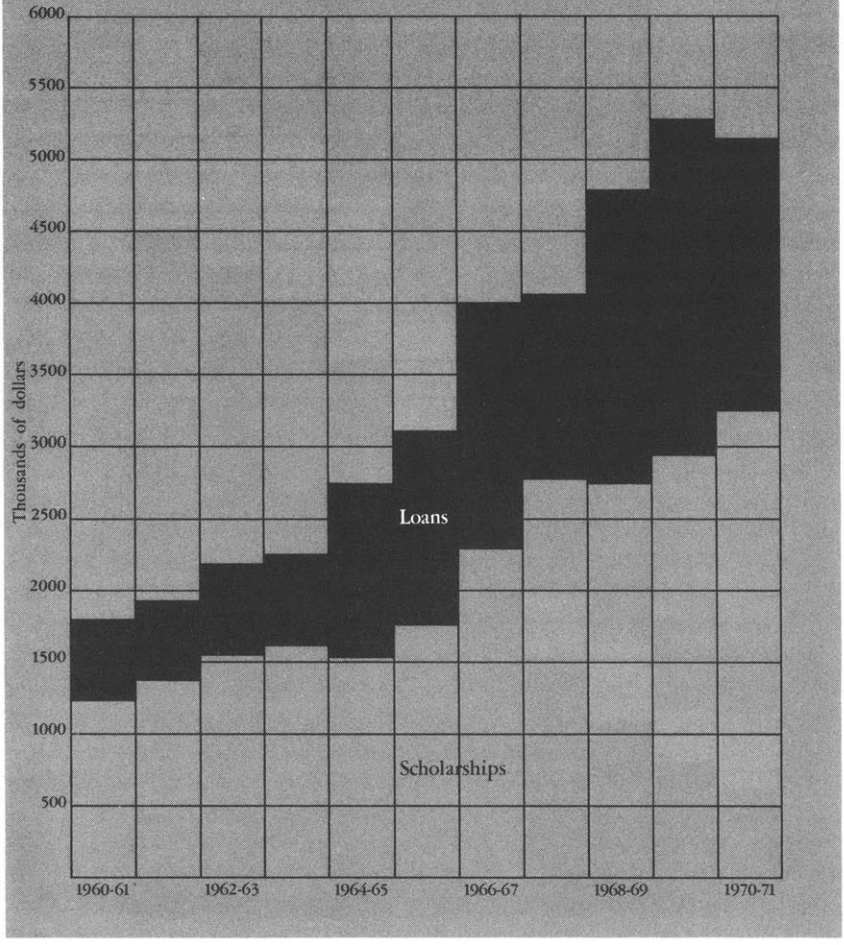
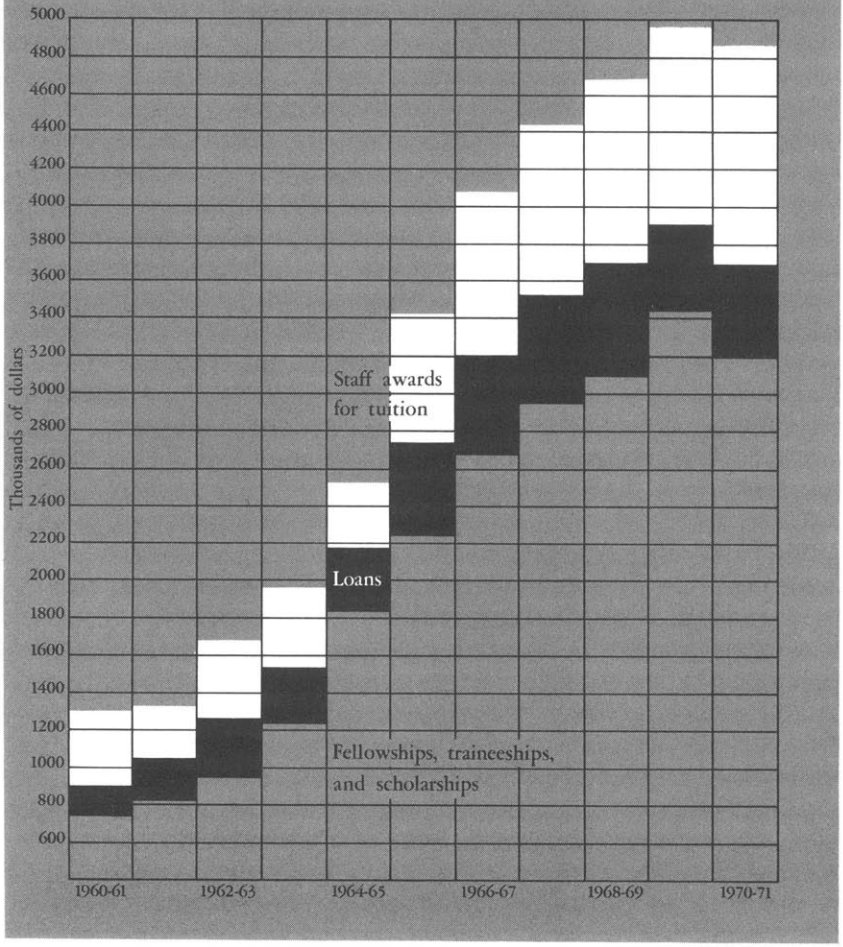


FIGURE 2

FINANCIAL AID TO GRADUATE STUDENTS
AWARDED BY M.I.T., 1961-1971



from 500 the year before; the number of doctoral candidates dropped from 301 to 252. Only Master's degree candidates came for interviews in equal numbers.

Relatively few students who looked for jobs ended up unemployed, but unemployment was a significant factor in some fields. Doctoral candidates in chemistry were particularly hard hit. Only one out of 21 students who received a Ph.D. degree in chemistry in June obtained a regular faculty position; none found a job in industry. Most found temporary appointments as postdoctoral fellows and research associates.

Alumni using the Placement Bureau jumped by a third, from 728 in 1969–70 to 972. Ninety per cent of those registering were either out of work or soon expected to be. The Bureau conducted interviews in New York for alumni located there and a member of the staff spent three days counseling alumni in Seattle. The Bureau joined with the Alumni Association in organizing a two-day seminar in April on career prospects in different fields. Starting in May, a *Bulletin of Available M.I.T. Graduates* was mailed to employers with summary data on alumni looking for employment. The *Bulletin*, which omits individuals' names, has elicited requests for resumes from a promising number of companies.

FINANCES

As reported by the Treasurer, the total financial operations of the Institute, including sponsored research, were maintained at very near the level of 1969–70. Educational and general expenses — excluding the direct expenses of departmental and interdepartmental research, of the Lincoln Laboratory, and of the Charles Stark Draper Laboratory — amounted to $71,945,000 during 1970–71 as compared to $66,012,000 in 1969–70. Reflected in the finances of the Institute was the increase in the use of general purpose funds of $4,907,000, compared with $4,636,000 in the preceding year to meet the greater expenses of instruction, departmental sponsored research, and related plant and administration activities.

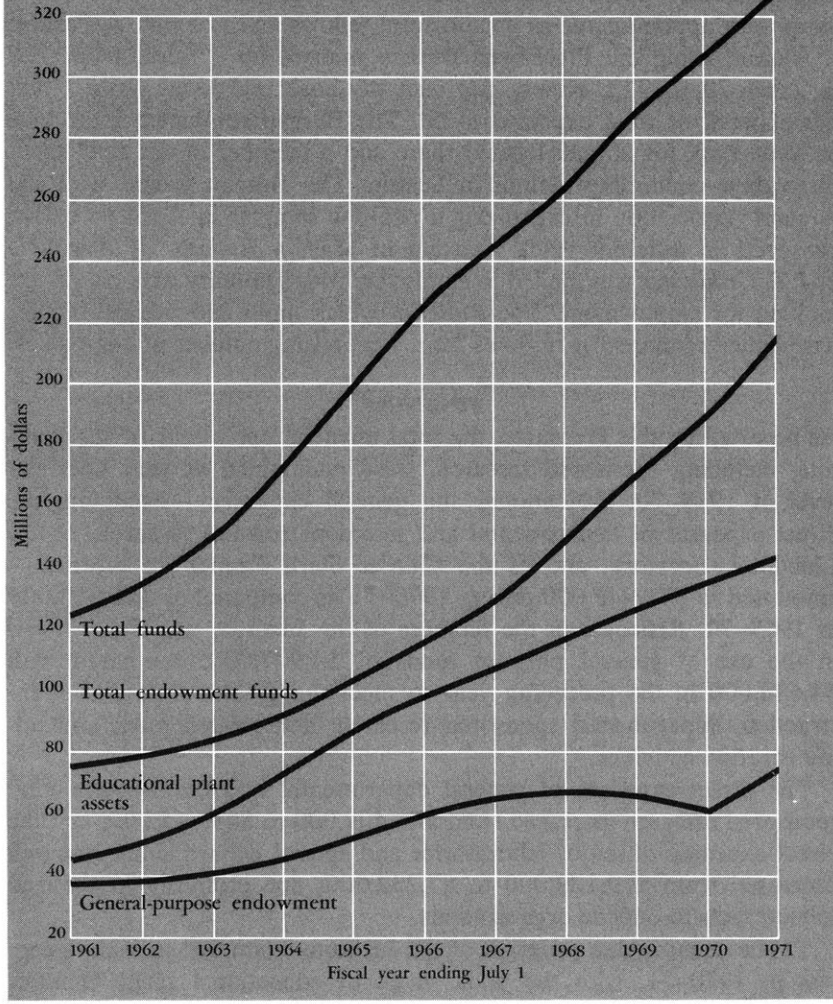
The direct expenses of general departmental and interdepartmental sponsored research increased from $46,409,000 to $49,015,000, and the direct expenses of major laboratories and special departmental research decreased from $99,129,000 to 87,232,000, due primarily to reduced subcontracts to outside organizations.

The construction program of the Institute continued to make progress in 1970–71, with the book value of educational plant facilities increasing from $136,926,000 to $143,120,000.

At the end of the fiscal year, the Institute's investments, excluding retirement funds, had a book value of $316,176,000 and a market value

FIGURE 3

THE GROWTH OF M.I.T.'S FUNDS AND PLANT ASSETS, 1961-1971



of $395,428,000. This compares to book and market totals of $290,693,000 and $320,330,000 last year.

Figure 3 shows the growth of M.I.T.'s funds and plant assets from 1961 to 1971. The increase in endowment for general purposes in 1970–71 resulted principally from the transfer to endowment of the larger part of the final receipt from the estate of Mrs. Katharine Dexter McCormick.

GIFTS

Gifts, grants, and bequests to M.I.T. from private donors increased to $39,637,000 during fiscal 1970–71 as compared with $19,621,000 for the previous year, as a result of the receipt of partial distributions from three bequests. The former figure includes unrestricted direct gifts to the Alumni Fund of $1,010,000, which made up a part of the total of $2,564,000 reported by the Alumni Fund in 1970–71.

PHYSICAL PLANT AND CAMPUS ENVIRONMENT

A number of new academic and residence facilities and a variety of supporting projects were dedicated, completed, or renovated, while others were either under construction or being planned. Among the most important of these physical changes were those involving on-campus housing.

In November, the Frank S. MacGregor House was dedicated, marking the first new major housing construction for men since 1947. This new residence, the product of seven years of thoughtful discussions and planning, has important benefits for the quality of student life at M.I.T. Its acceptance by the Institute was to the tune of bagpipes and a handsome display of the MacGregor tartan.

The Westgate II graduate student residence is under construction and should be completed by next September. The renovation of Burton-Conner House was completed earlier than expected, permitting the House to be available to students returning in the fall of 1971. The renewal of this building, which can house 344 undergraduate students in suite-type accommodations, has been done with imagination and taste and should give pleasure and service to many generations of students.

In a different vein, under construction are the electrical engineering and communications research building, which is now happily ahead of schedule, and a group of central utilities that will provide greater steam and refrigeration capacity for M.I.T.'s buildings.

The Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics was dedicated in October, 1970. This construction involved the addition of two floors to Building 48 and a major refurbishing of existing laboratory facilities.

The M.I.T. Press occupied new and expanded facilities on Carleton

Street in the fall. The Press now has facilities befitting its position as an important and vigorous university press.

On Briggs Field the J. B. Carr indoor tennis facility has made indoor tennis a reality. The facility, housed in an inflatable structure, accommodates four tennis courts.

Nearing completion at the Institute's field station in Westford is a new astrophysical observatory. The Observatory, which will house 16″ and 24″ telescopes, was made possible by a gift of Mr. George R. Wallace, Jr., '13.

Several major renovations of Institute facilities were accomplished this year, giving new life and utility to our versatile buildings. Most notable among these were in the Eastman Laboratories for the Department of Chemistry and in the Rogers Building for the Department of Urban Studies and Planning.

The internal and external environment of the Institute changed in a variety of ways, all of which have sought to improve the quality of life at M.I.T. One of the most significant visual changes has been the conversion of the Institute's main corridors from monochromatic gray to a gallery of light and color into which students and faculty have brought exhibitions of student work and departmental projects. Contemporary communications media installed in the corridors are being used to publicize the rich variety of activities at the Institute.

A modified version of the plan for the Massachusetts Avenue crossing and landscape project was completed just before the close of the school year. New, hardy Japanese Zelkova trees have replaced the dead and dying elms along the Avenue, and new bus shelters, tubs of bright flowers, and new lighting and signal devices are all in place.

Another landscape addition deserves special mention. In memory of Mrs. Frances Ropes Williams of the Class of 1904, her daughter, Miss Constance Williams, '64, dedicated to the Institute a display of Hosta plants developed by the late Mrs. Williams. This delightful addition to our landscape has been installed in the courtyard adjacent to the Maclaurin Building.

Changes have been made in the Housing and Dining Services. In response to student input, the Dining Service has agreed upon a campus-wide program of optional food contracts on a one-year experimental basis beginning this fall.

PERSONNEL CHANGES
FROM OCTOBER 1, 1970, TO SEPTEMBER 30, 1971

CORPORATION

DEATHS

MERVIN J. KELLY

WHITNEY M. YOUNG, JR.

APPOINTMENTS

PAUL M. COOK
Member

WILLIAM S. EDGERLY
Member

JAMES A. HESTER
Member

CHRISTINA H. JANSEN
Member

KENNETH H. OLSEN
Member

MICHAEL V. SAWYER
Member

LAURENCE STORCH
Member

GEORGE W. THORN
Member

PAMELA T. WHITMAN
Member

CHANGES OF APPOINTMENT

JAMES R. KILLIAN, JR.
Life Member

ELECTIONS

PAUL E. GRAY
Chancellor

HOWARD W. JOHNSON
Chairman of the Corporation

PAUL V. KEYSER
President of the Alumni Association

JAMES R. KILLIAN, JR.
Honorary Chairman of the Corporation

JEROME B. WIESNER
President

FACULTY

DEATHS

CHARLES D. CORYELL
Professor in Chemistry

THEOS J. THOMPSON
Professor in Nuclear Engineering

GREGORY TUCKER
Professor in Humanities

RETIREMENTS

LAWRENCE B. ANDERSON
Dean of the School of Architecture and Planning

E. LEE GAMBLE
Professor in Chemistry

TRUMAN S. GRAY
Professor in Electrical Engineering

JOHN T. NICKERSON
Professor in Nutrition and Food Science

RESIGNATIONS

Professors:

DONALD C. CARROLL
Sloan School of Management

PAUL H. COOTNER
Sloan School of Management

PHILIP L. DE BRUYN
Metallurgy and Materials Science

HERBERT J. GANS
Urban Studies and Planning

HERBERT O. HOUSE
Chemistry

ERIC REISSNER
Mathematics

HERBERT H. WOODSON
Electrical Engineering

Associate Professors:

DONALD W. ANDERSON
Mathematics

CHARLES A. BERG
Mechanical Engineering

WILLIAM K. BERTRAM
Physics

JOHN B. BRONZAN
Physics

JOEL E. BROWN
Biology

THEODORE P. LABUZA
Nutrition and Food Science

MARK A. LEVENSKY
Humanities

BERNARD MASKIT
Mathematics

MARLAN O. SCULLY
Physics

THOMAS O. ZIEBOLD
Nuclear Engineering

PAUL ZWEIG
Humanities

Assistant Professors:

DAVID M. CHIPMAN
Chemistry

FRANCIS R. COTTRELL
Chemical Engineering

ANTHONY DUGDALE
Architecture

ROBERT R. FENICHEL
Electrical Engineering

ROE W. GOODMAN
Mathematics

ALLEN GRAUBARD
Humanities

MARTIN E. HELLMAN
Electrical Engineering

DAVID L. HOLT
Metallurgy and Materials Science

WILLIAM J. INCE
Electrical Engineering

WALLACE M. MANHEIMER
Physics

SIEGFRIED T. MAYR
Chemical Engineering

JACOB L. MEIRY
Aeronautics and Astronautics

WILLIAM H. MOORE
Physics

N. THOMAS OLSON
Nuclear Engineering

MICHAEL S. PATERSON
Mathematics

PETER B. RHINES
Meteorology

WILLIAM K. ROSE
Physics

BARRY H. ROSOF
Metallurgy and Materials Science

JOSEPH H. STAFFORD
Civil Engineering

CARL V. SWANSON
Sloan School of Management

CHRISTOPHER K. TAM
Aeronautics and Astronautics

KENNETH B. TAYLOR
Biology

CHIA-GEE WANG
Physics

COLIN G. WHITNEY
Electrical Engineering

DANA E. WILSON
Nutrition and Food Science

PROMOTIONS

To Professor:

JACK E. BALDWIN
Chemistry

ABRAHAM BERS
Electrical Engineering

JEROME J. CONNOR, JR.
Civil Engineering

DAVID M. EPSTEIN
Humanities

KENNETH L. HALE
Foreign Literatures and Linguistics

ROBERT E. JONES
Foreign Literatures and Linguistics

ALVIN C. KIBEL
Humanities

ROBERT S. LEES
Nutrition and Food Science

KOICHI MASUBUCHI
Ocean Engineering

JOHN R. MYER
Architecture

LISA R. PEATTIE
Urban Studies and Planning

SHELDON PENMAN
Biology

DANIEL G. QUILLEN
Mathematics

PETER H. SCHILLER
Psychology

ROBERT W. SIMPSON
Aeronautics and Astronautics

KENNETH A. SMITH
Chemical Engineering

MAURICE K. SMITH
Architecture

M. NAFI TOKSOZ
Earth and Planetary Sciences

GEORGE M. WHITESIDES
Chemistry

DAVID G. WILSON
Mechanical Engineering

To Associate Professor:

SUZANNE BERGER
Political Science

LOUIS L. BUCCIARELLI
Aeronautics and Astronautics

STEPHEN K. BURNS
Electrical Engineering

JOHN W. DEVANNEY III
Ocean Engineering

JOHN J. DEYST, JR.
Aeronautics and Astronautics

ROBERT S. FREEMAN
Humanities

DEVENDRA P. GARG
Mechanical Engineering

JULIUS L. GOLDSTEIN
Electrical Engineering

ROBERT GOODMAN
Architecture

LANGLEY C. KEYES, JR.
Urban Studies and Planning

ROSALIND E. KRAUSS
Architecture

JAMES D. LITSTER
Physics

HARVEY F. LODISH
Biology

THOMAS B. MCCORD
Earth and Planetary Sciences

MICHAEL MODELL
Chemical Engineering

JAMES P. MORAN
Aeronautics and Astronautics

JOEL MOSES
Electrical Engineering

FRANCIS O'BRIEN
Athletics

RONALD R. PARKER
Electrical Engineering

GERALD A. POGUE
Sloan School of Management

IRWIN M. RUBIN
Sloan School of Management

PAUL R. SCHIMMEL
Biology

ANTHONY J. SINSKEY
Nutrition and Food Science

H. EUGENE STANLEY
Physics

JOHN A. STEFFIAN
Architecture

JOSEPH M. SUSSMAN
Civil Engineering

NEIL E. TODREAS
Nuclear Engineering

PIN TONG
Aeronautics and Astronautics

PREETINDER S. VIRK
Chemical Engineering

JAMES N. WALPOLE
Electrical Engineering

To Assistant Professor:

DONALD H. BELL
Humanities

ROLAND DAVIES
Nutrition and Food Science

JOSEPH FERREIRA
Urban Studies and Planning

CURTIS GREENE
Mathematics

BRENDAN M. HARLEY
Civil Engineering

ROBERT S. PINDYCK
Sloan School of Management

RONALD G. PRINN
Meteorology

MURAT R. SERTEL
Sloan School of Management

SEAN C. SOLOMON
Earth and Planetary Sciences

DONALD SUR
Humanities

LAWRENCE E. SUSSKIND
Urban Studies and Planning

TERRY A. WINOGRAD
Electrical Engineering

LEWIS D. WURGAFT
Humanities

CHANGES OF APPOINTMENT

ARNOLD E. AMSTUTZ
Senior Lecturer in
Sloan School of Management

ULRICH J. BECKER
Assistant Professor in Physics

ARDEN L. BEMENT
Professor of Nuclear Materials
in Departments of Nuclear Engineering
and Metallurgy and Materials Science

ARTHUR BERNHARDT
Assistant Professor in Architecture

JOHN F. BREEDIS
Visiting Lecturer in
Metallurgy and Materials Science

LESLIE G. BROMWELL
Research Associate in Civil Engineering

CATHERINE V. CHVANY
Assistant Professor in
Foreign Literatures and Linguistics

JAMES R. CLOW
Lecturer in Physics

PETER D. DECICCO
Lecturer in Physics

GERALD P. DINEEN
Professor in Electrical Engineering
and Director of Lincoln Laboratory

IRA DYER
Professor in Ocean Engineering

ARTHUR EVANS, JR.
Lecturer in Electrical Engineering

ROBERT M. FOGELSON
Associate Professor in Urban Studies
and Planning

THAYER C. FRENCH
Visiting Scientist in Chemistry

THOMAS P. GERRITY
Lecturer in Sloan School of
Management

ROBERT GILMORE
Lecturer in Physics

CHRISTOPHER GOETZ
Assistant Professor in Earth and
Planetary Sciences

ELIAS P. GYFTOPOULOS
Ford Professor of Engineering
in Nuclear Engineering

HANS H. HARMS
Assistant Professor in Architecture

PHILIP B. HERR
Associate Professor in
Urban Studies and Planning

UNO K. INGARD
Professor in Departments of Physics
and Aeronautics and Astronautics

ROBERT J. KOLENKOW
Visiting Scientist in Physics

STANLEY KOWALSKI
Senior Research Scientist in Physics

ROY LAMSON
Class of 1922 Professor in Humanities

RICHARD C. LARSON
Assistant Professor in Departments of
Electrical Engineering and Urban
Studies and Planning

HEATHER N. LECHTMAN
Assistant Professor in Humanities

NORMAN LEVINSON
Institute Professor

MARIA C. LINDER
Assistant Professor in Nutrition
and Food Science

ROBERT W. MANN
Kenneth J. Germeshausen Professor
in Mechanical Engineering

HERMAN P. MEISSNER
Lammot du Pont Professor of Chemical
Engineering and Executive Officer of
Department of Chemical Engineering

PATRICK MORREAU
Lecturer in Architecture

JOHN W. NEGELE
Assistant Professor in Physics

AMEDEO R. ODONI
Assistant Professor in Aeronautics
and Astronautics

FRANK A. PRESS
Robert R. Shrock Professor of Earth and
Planetary Sciences and Head of the
Department of Earth and Planetary
Sciences

JOHN ROSS
Frederick G. Keyes Professor of Physical
Chemistry in Department of Chemistry

LEO SARTORI
D.S.R. Staff Member

CAMPBELL L. SEARLE
Clarence Joseph LeBel Professor in
Electrical Engineering

ISADORE M. SINGER
Norbert Wiener Professor in Mathematics

DENNIS P. SULLIVAN
Professor in Mathematics

WALTER D. SYNIUTA
Lecturer in Mechanical Engineering

KOSTA M. TSIPIS
Research Associate in Biology

KANG-LUNG WANG
Assistant Professor in Electrical Engineering

BRUCE D. WEDLOCK
Lecturer in Electrical Engineering

LEON S. WHITE
Senior Research Associate in Sloan School of Management

DANIEL E. WHITNEY
du Pont Associate Professor in Mechanical Engineering

DAVID R. WONES
Research Affiliate in Earth and Planetary Sciences

NEW FACULTY APPOINTMENTS

Professor:

WALTER D. BURNHAM
Political Science

ALBERTO P. CALDERÓN
Mathematics

JOHN F. MCCARTHY, JR.
Aeronautics and Astronautics

GORDON H. PETTENGILL
Earth and Planetary Sciences

Associate Professor:

GUSTAV SCHONFELD
Nutrition and Food Science

Assistant Professor:

EYTAN BAROUCH
Mathematics

DONALD S. BARTON
Physics

JOHN W. BELCHER
Physics

HANS D. BETZ
Physics

NED J. BLOCK
Philosophy

HARVEY K. BOWEN
Metallurgy and Materials Science

WAYNE A. CORNELIUS
Political Science

JAMES M. FLINK
Nutrition and Food Science

JOHN E. GARLANGER
Civil Engineering

MICHAEL W. GOLAY
Nuclear Engineering

GARY A. HACK
Urban Studies and Planning

SIDNEY M. HECHT
Chemistry

CARL E. HEWITT
Electrical Engineering

ROBERT M. HOLLISTER
Urban Studies and Planning

JAMES T. KNEAFSEY
Civil Engineering

EUGENE M. KLEINBERG
Mathematics

STEPHEN P. LOUTREL
Mechanical Engineering

OLE S. MADSEN
Civil Engineering

THOMAS L. MAGNANTI
Sloan School of Management

MICHAEL O'HARE
Urban Studies and Planning

GARY J. POWERS
Chemical Engineering

JOHN M. ROSS
Political Science

ARTHUR P. SOLOMON
Urban Studies and Planning

ROBERT J. TAYLOR
Physics

JOHN B. VANDER SANDE
Metallurgy and Materials Science

BARRY L. VERCOE
Humanities

VISITING FACULTY

Visiting Professors:

FRANS ALTING VON GEUSAU
Political Science

WILLIAM A. ARROWSMITH
Humanities and Consultant to the Commission on M.I.T. Education

PRANAB K. BARDHAN
Economics

ALAN D. BERG
Nutrition and Food Science

HANS G. BOMAN
Biology

SUBRAHMAMYAN CHANDRASEKHAR
Mathematics

CHU-I CHANG
Electrical Engineering

ROBERT T. CHIEN
Electrical Engineering

JOHN W. CHRISTIAN
Metallurgy and Materials Science

PHILLIP DAVID
Urban Studies and Planning

GIANCARLO DECARLO
Architecture

WILLIAM DOEBELE
Urban Studies and Planning

NESTOR F. GONZALEZ-CADAVID
Biology

VICTOR B. GOODRICH, JR.
Aerospace Studies and Director of the Air Force R.O.T.C.

LOUIS GUTTMAN
Political Science

LILLIAN HELLMAN
Humanities

LOUIS F. HENRIQUES
Ford Professor of History in Humanities

BROOKE HINDLE
Elizabeth and James Killian 1926 Professor in Humanities

ALBERT G. HINES
Economics

SHIVARAM D. JOSHI
Foreign Literatures and Linguistics

HANS KLENOW
Biology

SHOSHICHI KOBAYASHI
Mathematics

DONALD L. KREIDER
Mathematics

ERNST NOLTE
Ford Professor of History in Humanities

NILS H. NORRBIN
Ocean Engineering

MAX F. PERUTZ
Biology

NIRMALA PRAKASH
Mathematics

ISAIAS RAW
Biology

HELMUT SCHUSTER
Economics

RONALD L. SHREVE
Earth and Planetary Sciences

ROBERT S. SILVER
Mechanical Engineering

PHILIP SPORN
Schools of Engineering and Management

SEIYA UYEDA
Earth and Planetary Sciences

AGIENUS VRIJ
Chemical Engineering

HENRY WALLMAN
Electrical Engineering

COLIN S. WILSON
Bemis Professor in Architecture

Visiting Associate Professors:

MANUEL BLUM
Electrical Engineering

HOWARD H. BROWN
Physics

STEPHEN S. COHEN
Urban Studies and Planning

RICHARD W. COTTLE
Sloan School of Management

THOMAS M. COVER
Electrical Engineering

MICHAEL FRIED
Mathematics

IRMFRIED HARTMANN
Electrical Engineering

HIKOYA HAYATSU
Biology

GERHARD A. HÖFLE
Chemistry

RUSSEL C. JONES
Civil Engineering

BUDUGUR LAKSHMINARAYANA
Aeronautics and Astronautics

JOHN H. PETERS
Sloan School of Management

JAMES H. PORTER
Chemical Engineering

IGNACIO RODRIGUEZ-ITURBE
Civil Engineering

SAMUEL F. SAMPSON
Urban Studies and Planning

MILTON J. SCHLESINGER
Biology

CHUNG-YI SHEN
Electrical Engineering

MARTIN L. SHOOMAN
Electrical Engineering

JAMES H. T. WU
Mechanical Engineering

Visiting Assistant Professors:

RALPH H. CROSS
Civil Engineering

EDWARD J. EPSTEIN
Political Science

LARRY J. GERSTEIN
Mathematics

HARTMUT GREBE
Electrical Engineering

GEORG R. PHILLIPS
Biology

YURII P. PLOTNIKOV
Aeronautics and Astronautics

SONDRA SCHLESINGER
Biology

KEITH D. STOLZENBACH
Civil Engineering

DANIEL WEISBERG
Urban Studies and Planning

ERICH K. O. ZAHN
Sloan School of Management

ADMINISTRATION

DEATHS

THOMAS J. CRANE
Fiscal Officer
Division of Sponsored Research

RETIREMENTS

ALFRED PEET ROGERS
Property Officer
Division of Sponsored Research

DORIS S. EVANS
Director of Alumni Records
Alumni Association

CONSTANCE D. BOYD
Assistant to the Director
M.I.T. Press

RESIGNATIONS

GORDON L. BRIGHAM
Assistant Planning Officer

MARJORIE A. BUTLER
Assistant to the Director
Registrar's Office

JANICE F. CLARKE
Assistant to the Director
Financial Aid Office

JOHN P. DONAHUE
Assistant Comptroller
Office of the Comptroller

LINDA C. FITZPATRICK
Planning Aid
Planning Office

JAMES A. HALLORAN
Staff Programmer
Office of Administrative Information Systems

JAY C. HAMMERNESS
Assistant Dean for Student Affairs

FRANCIS HARTLEY IV
Assistant to the Vice President and Secretary of the Institute

RICHARD C. HODGSON
Assistant Director
Division of Sponsored Research

DAVID A. KIBBEY
Director of Exhibitions
Committee on the Visual Arts

MARGARET A. LAMBRINIDES
Administrative Staff
Planning Office

PAUL S. OLES
Architect-Programmer
Planning Office

GEORGE F. PRENDERGAST
Staff Accountant
Comptroller's Accounting Office

ROBERT R. RAGUSA, JR.
Investment Accountant
Office of the Comptroller

FRANCIS F. SPINKS
Assistant for Environmental Studies
Planning Office

SIDRA STICH
Registrar of the Collection
Committee on the Visual Arts

WAYNE A. STUART
Assistant for Studies of Undergraduate Education
Undergraduate Planning Office

WILLIAM K. STUCKEY
Associate Director
Office of Public Relations

JUANITA STULLER
Assistant Director of Admissions

BRUCE SZKELENNIK
Credit Manager
M.I.T. Press

DIETMAR R. WINKLER
Graphic Designer
Office of Publications

APPOINTMENTS AND CHANGES

EDWARD AGRO
Staff Editor
M.I.T. Press

BARBARA ANKENY
Senior Editor
M.I.T. Press

PETER BANDMAN
Site Planner
Planning Office

ARTHUR L. BEALS
Assistant to the Director
Housing and Dining Office

NANCY J. BECKLEY
Project Programmer
Planning Office

GLENN A. BERCHTOLD
Professor and Head of the Department of Chemistry

ROBERT D. BLAKE
Assistant to the Vice President and Secretary of the Institute

PAUL M. BLANCHARD
Assistant Superintendent of Electrical Services, Physical Plant

DOROTHY L. BOWE
Assistant Director
Student Financial Aid Office

PENNY M. BOWMAN
Programmer
Office of Administrative Information Systems

LOUIS B. D. BRAIDA
Assistant Professor and Executive Officer in Electrical Engineering

JAMES D. BRUCE
Associate Professor in Electrical Engineering and Associate Dean of the School of Engineering

ROBERT M. BYERS
Director of News Office
Acting Director
Institute Information Services

DAVID M. CARNEY
Manager of Planning and Administration
Office of Administrative Information Systems

RICHARD L. CARTWRIGHT
Professor and Head of the Department of Philosophy

ROBERT N. CLARK
Manager of Operations
Office of Administrative Information Systems

JAMES W. COLEMAN
Director of Graphic Arts

ARTHUR J. COLLIAS
Administrative Officer
Center for Advanced Engineering Studies

ALLEN M. COMMEAU
Grants Accountant
Comptroller's Accounting Office

WILBUR B. DAVENPORT
Professor in Electrical Engineering and Associate Head for Electrical Science and Engineering

WENDELL A. DERRY
Property Officer
Division of Sponsored Research

WILLIAM R. DICKSON
Director of Physical Plant

RICHARD P. DOBER
Director, Long Range Planning
Planning Office

MARY S. DOEBELE
Senior Community Planner
Planning Office

WILLIAM J. DUGGAN
Assistant Comptroller

GERALD N. EDWARDSEN
Assistant Sales Manager
M.I.T. Press

ROBERT M. FANO
Ford Professor of Engineering in Electrical Engineering and Associate Head of Computer Science and Engineering

EDWARD FREDKIN
Professor in Electrical Engineering and Director of Project MAC

BERNARD J. FRIEDEN
Professor in Urban Studies and Planning and Director of Joint Center for Urban Studies of the Massachusetts Institute of Technology and Harvard University

PAUL E. GRAY
Dean of the School of Engineering, December 1, 1970
Chancellor, July 1, 1971

LILLIAN H. GUILIANA
Administrative Assistant
Office of the President and Chancellor

EVERETT E. HAGEN
Professor of Economics and Political Science and Director of the Center for International Studies

INA M. HARMON
Staff Accountant
Comptroller's Accounting Office

JON E. HARTSHORNE
Assistant to the Dean for Student Affairs

KENNETH M. HOFFMAN
Professor and Head of the Department of Mathematics

LAWRENCE A. HOUGH
Assistant Director
Student Financial Aid Office

ROBERT ILFELD
Associate Director for Executive Development Programs in the Sloan School of Management

DEAN L. JACOBY
Special Assistant for Policy Review
Office of the Vice President, Administration and Personnel

HOWARD W. JOHNSON
Chairman of the Corporation
Special Faculty Professor

PAUL E. JOHNSON
Associate Director
Institute Information Services

FRANK S. JONES
Ford Professor of Urban Affairs in Civil Engineering and Director of the M.I.T. Community Fellows Program

ALFRED A. H. KEIL
Professor and Head of the Department of Ocean Engineering and Dean of the School of Engineering

BRENDA KELLY
Associate Editor
Technology Review

PHILIP J. KEOHAN
Associate Comptroller

CHARLES F. KIEFER, JR.
Assistant to the Director
Division of Sponsored Research

MELVIN H. KING
Lecturer in Urban Studies and Planning and Associate Director of the Community Fellows Program

DONALD S. KIRSCHLING
Systems Analyst
Office of Administrative Information Systems

MALCOLM G. KISPERT
Institute Secretary

WALTER L. KOLTUN
Assistant Director for Resources
Harvard-M.I.T. Program in Health Sciences and Technology

JANET D. KREILING
Associate Editor of *Technology Review*
Alumni Association

GEORGE J. LABRECHE, JR.
Assistant to the Dean for Student Affairs

ARTHUR J. LIDSKY
Administrative Staff
Planning Office

JAMES L. LINDERMAN
Manager of Technical Services
Office of Administrative Information Systems

KASHA LINVILLE
Director of Exhibitions
Committee on the Visual Arts

KATHRYN W. LOMBARDI
Associate
Analytical Studies Group

EDWARD A. MASON
Professor and Head of the Department of Nuclear Engineering

FRANCIS H. MCGRORY
Associate Director
Division of Sponsored Research

NOREEN J. MCSORLEY
Assistant to the Dean
of the School of Science

EDWARD G. MARCATO
Assistant to the Director
Division of Sponsored Research

KAREN J. MATHIASEN
Administrative Assistant
Office of the President and Chancellor

STANLEY MILLER
Manager of Systems
Office of Administrative Information Systems

MARVIN L. MINSKY
Professor in Electrical Engineering and Co-Director of Artificial Intelligence Laboratory

MAXINE D. MOFFETT
Basic Education Instructor
Personnel-Technical Training

BERNARD A. MORRIS
Counselor-Training Section
Office of Personnel Relations

MARY L. MORRISSEY
Administrative Assistant for Information
Institute Information Services

BENJAMIN F. MOULTRIE
Assistant Director
Student Financial Aid Office

JOHN F. O'BRIEN
Administrative Staff
Comptroller's Accounting

JOEL ORLEN
Assistant to the Provost

GORDON W. ORO
Administrative Officer in Nuclear Engineering

HELEN OSBORNE
Managing Editor
M.I.T. Press

DOROTHY B. OWUSU
Assistant to the Dean
of the Graduate School

SEYMOUR A. PAPERT
Professor in Mathematics and
Co-Director of Artificial Intelligence Laboratory

JOSEPH M. PATTEN
Associate Director of Fiscal Planning

THOMAS E. POPE
Project Assistant
Planning Office

WILLIAM L. PORTER
Professor in Departments of Architecture and Urban Studies and Planning and Dean of the School of Architecture and Planning

VERNON A. RAINE
Assistant Director
Graphic Arts

WALTER A. ROSENBLITH
Professor in Electrical Engineering and Provost

RICHARD D. SALMON
Assistant Financial Director
M.I.T. Press

MARTIN M. SANTA
Patent Attorney
Division of Sponsored Research

ANNE SAYER
Publicity Director
M.I.T. Press

JEREMY F. SHAPIRO
Associate Professor in Sloan School of Management and Associate Director of Operations Research Center

ROBERT SHAW
Patent Attorney
Division of Sponsored Research

ANNE SHEPLEY
Administrative Officer in Architecture

CONSTANTINE B. SIMONIDES
Vice President

ARTHUR A. SMITH
General Counsel
Division of Sponsored Research

PETER M. SPACKMAN
Assistant Director of the News Office
Institute Information Services

LINDA STANTIAL
Assistant Alumni Placement Officer
Assistant Director of Placement

RONALD S. STONE
Executive Officer of the Graduate School

INDIA S. THOMPSON
Personnel Representative
Office of Personnel Relations

ROBERT L. VAN DE PITTE
Assistant to the Director
Division of Sponsored Research

JEROME B. WIESNER
President

GERALD L. WILSON
Associate Professor in Electrical Engineering and Director of Electric Power Systems
Engineering Laboratory

KERRY B. WILSON
Assistant to the Director
Office of Personnel Relations

BARBARA WOLLAN
Administrative Assistant
Office of the President and Chancellor

JOHN M. WYNNE
Vice President for Administration and Personnel

JERILEA A. ZEMPEL
Administrative Assistant
Committee on the Visual Arts

PROVOST

After the turbulence of the prior year, the 1970-71 academic year was a time for assessing the issues which had been brought to everyone's attention so vividly and for beginning to redirect some of the Institute's resources to meet an emerging new set of priorities.

Largely because of substantial financial support from the IBM Corporation and from Dr. Edwin Land, we have been able to continue to experiment with alternate modes of undergraduate education. The Unified Science Study Program and the Experimental Study Group, which provide coherent, full-time programs for participating students, entered their second years, and have added programs for sophomores as well as freshmen. They now provide alternatives to the regular program of the first two years at M.I.T. A third such alternative, the Concourse Program, will be offered for the first time in the fall of 1971.

Several other experiments were undertaken with the purposes of breaking into the traditional academic procedures and designing new modes of interaction between students and faculty and between students and the material they study. Some of these activities are described in the following section entitled Innovation and Reform in Undergraduate Education. Conspicuously successful has been the Undergraduate Research Opportunities Program which provides students with the experience of working as junior colleagues in ongoing faculty research activities. More than 300 undergraduates have participated during each term of the past year. These programs were funded largely by the Land Grant and IBM funds.

The activities and experiences of these experimental programs have influenced the deliberations of the Task Force on Education, chaired by

Professor Hartley Rogers, which is shortly expected to recommend substantial changes in the undergraduate program.

Some funds are becoming available for study and research in areas of national social concern, including environmental problems, health problems, and the problems that government at all levels faces in delivering public services, but it is still not possible to generate programs matched to the scale of the social need. Over the past few years, in spite of the support problems, many members of the faculty and their students have been turning their attention to the application of their disciplines to these concerns. This trend is evident in the numerous activities of the Harvard-M.I.T. Joint Center for Urban Affairs, the Center for Operations Research, the Urban Systems Laboratory, and the Harvard-M.I.T. Program in Health Sciences and Technology, whose reports follow later in this section.

Many of the research laboratories whose reports are in this section are continuing to face strained financial conditions, but all are finding ways to continue their major efforts. Unfortunately the financial difficulties are causing the laboratories to defer the procurement of needed new equipment, a procedure which is already beginning to reduce the effectiveness of their research activities. Even more serious is the fact that the various research groups have less money available to support graduate students as research assistants. This limitation on graduate student support by the research programs added to the severe cut-back in Federal training grants and fellowships has made it extremely difficult for many outstanding students to find the support necessary for them to attend graduate school. Because of this, M.I.T. awarded a number of Sloan Research Fellowships supported by funds from the Sloan Basic Research Fund. It was not possible completely to compensate for the reduction in Federal student support and consequently there has been a modest reduction in the size of the graduate school enrollment.

In spite of the financial strains it was a good year. Attention was focused on academic problems and both the teaching and research activities went forward with vigor as the reports that follow indicate.

JEROME B. WIESNER

FRANCIS BITTER NATIONAL MAGNET LABORATORY

Primary sponsorship of the Laboratory was transferred from the Air Force Office of Scientific Research to the National Science Foundation on June 30, 1971. The understanding support and encouragement received over the last eleven years from the Air Force is gratefully acknowl-

edged. AFOSR continues to support a specialized research program at the Laboratory on soft X-ray sources and detectors. Budgetary considerations still limit the operation of the magnet facility to half of its previous schedule.

The ALCATOR experimental thermonuclear research machine, designed in collaboration with the Research Laboratory of Electronics, is now being assembled in the Laboratory. Testing of the major components will commence soon. A high power magnetically tunable Raman laser has been developed using a powerful CO_2 laser as a primary radiation source. This laser will be combined with a second CO_2 laser to provide an intense source tunable over a wide range in the far infrared region where existing tunable sources are extremely weak. A new superconducting tunneling technique has been developed which provides direct measurements of the effective spin density of states in magnetic materials. A program on the high magnetic field properties of magnetic semiconductors has been initiated. The Laboratory's new magnetically shielded room has been in active use for the study of the very weak magnetic fields of the heart and brain.

Five Ph.D. theses based entirely on work done at the Laboratory were completed during the year. During the January Independent Activities Period the Laboratory presented a one-week program on "The Marvels of Magnetism and Magnets" which was well attended.

BENJAMIN LAX

CAMBRIDGE ELECTRON ACCELERATOR

The Cambridge Electron Accelerator Laboratory is engaged in an exciting development of changing the accelerator into a colliding beam system. Counter-traveling beams of electrons and positrons are accelerated each to energies up to 3.5 GeV, stored in the accelerator and then switched through a bypass where they are made to collide head-on. In the first half of 1971, collisions between 2-GeV electrons and 2-GeV positrons have been observed, representing the highest energy achieved anywhere in such collisions and proving success in the development of several significant advances in accelerator technology. Experiments now being prepared by groups from C.E.A., M.I.T., Harvard University, and other institutions are scheduled to begin in May, 1972. The experiments are designed to study the basic electromagnetic interaction at smaller distances than has been possible before, and to explore the forces between photons and elementary particles in a new higher energy region.

KARL STRAUCH

CAMBRIDGE PROJECT

The Cambridge Project was established in June, 1969, as a cooperative effort to utilize digital computers to a fuller extent in both basic and applied behavioral sciences. The objectives of the Project are twofold: to develop useful individual computing tools needed in the behavioral sciences; and to assemble a Consistent System of computing tools that behavioral scientists may use interactively rather than in isolation.

The Project is a cooperative effort on the part of computer scientists, statisticians, and behavioral scientists from various specialties both at M.I.T. and Harvard University. The Project's staff of full-time employees has assumed the responsibility for the development of a framework for the Consistent System of computing tools, while the work on particular tools has become the responsibility of individual faculty members from various departments within the two universities. Approximately 60 members of both university faculties, as well as a large number of students and research personnel, participated in the work or served on advisory committees during the year.

The Project has finished the task of organizing itself, insofar as that task is ever finished. In addition to the Advisory Committee on Operations, an Advisory Committee on Policy and a number of *ad hoc* Working Groups dealing with technical questions were established. Most of the work on tool-making is now two years old and bearing fruit: tools of many kinds have been brought to the point where they can be fitted into the Consistent System as soon as the system is ready to receive them. In the meantime, many of the tools have been put into the form of free-standing programs that may be distributed to researchers elsewhere. Work on the Consistent System itself has been underway for about a year. During that time, a study group defined the long-term goals, a small exploratory system was completely shaken down, and plans for the ultimate system were established.

The main task for the third year will be collecting within the framework of the Consistent System the various tools the Project has been developing. This is the crucial test of the concept of consistent collection, and from that point of view, the coming year is a crucial one.

A complete account of the work of the Cambridge Project, both on individual tools and the Consistent System, is available in the Project's second *Annual Report.*

DOUWE B. YNTEMA

CENTER FOR ADVANCED VISUAL STUDIES

Though the beginning of the past year was a critical time for the Center due to diminishing funds, the end of the year closed with a confident note. The Center was assured of two years' support from the Kress Foundation and a matching fund for the next academic year from the National Endowment for the Arts and the Humanities. This budget security gives the Center its first chance to plan ahead carefully for an extended period of time.

In spite of the formidable survival problems, the year was one of significant achievements for the Center. The Fellows participated in some major international and national exhibitions and, parallel with their individual activities, were involved in the development of two major cooperative projects. One was initiated by an invitation from the Museum of Science and Industry of Chicago to present a large-scale exhibition of work done at the Center. In the process of exploring a scheme for the exhibition, the Fellows developed a plan for a major traveling exhibition entitled "Multiple Interaction Team" which would introduce a new kind of presentation technique for artistic work. The proposed traveling exhibition would utilize a wide range of technical competence and communication systems and would also create interfaces between artist and public that would go beyond the traditional notion of object and passive beholder, thus reaching a new intense level of public participation. Additionally the work presented in this new context would not be merely a display of independent artistic achievements but would have a dynamic group life of its own — an interacting synergetic total. Sample ideas for the exhibition include the creation of an environment which relates to temperature highs and lows in the area; an "Ecology of Sky Organ" which reads sky events and converts them to sound; and the temporary external transformation of various cultural monuments through illusionary simulation techniques.

The Fellows of the Center are also involved in the preparation and planning of a full-year program of environmental events for the Charles River. The purpose of the project is to refocus civic awareness on the potentially immense role of a river in urban life in general, and the Charles River in the life of Boston and Cambridge in particular. The project includes a great number of not yet existing uses of the River, as well as the utilization of some of the age-old ways in which a river can enrich the urban life.

Preparations were made to increase working contact with the Institute on a large scale, interdisciplinary level, both in programming seminars, forums, and symposiums dealing with the role of the arts in environmental

problems, and in projecting work teams with whom the artists at the Center could collaborate on environmental scale projects, pollution abatement, and so forth.

GYORGY KEPES

CENTER FOR MATERIALS SCIENCE AND ENGINEERING

The aims of the Center for Materials Science and Engineering are to encourage, promote, and support interdisciplinary research in materials. Since 1965, when the Center occupied the new Vannevar Bush Building, the following departments have become associated in the interdisciplinary work of the Center: Physics, Chemistry, Metallurgy and Materials Science, Aeronautics and Astronautics, and Civil, Chemical, Mechanical and Electrical Engineering. During the past year the number of faculty and staff associated with the Center was 82. One hundred and five advanced degrees were awarded to graduate students doing thesis research in materials under the supervision of faculty with the Center.

Research highlights, in highly abbreviated form, are given below. These in no way cover the many excellent programs in progress. The reader is referred to the *Annual Report on Research in Materials at MIT* for 1970-71.

SOLID STATE STUDIES

Professor Pratt reports that: 1) Lasing was achieved from optically pumped PbSe subjected to a uniaxial (110) stress at the different frequencies corresponding to the multiple energy gaps produced by applied stresses. The separate beams coming from the same optical cavity act as built-in local oscillators and greatly simplify the problem of detection and demodulation in optical communications. 2) A CO_2 laser has been used to render heat resistant dry spores biologically inactive. Evidently the weak hydrogen bonds that give the active macromolecules their particular character are broken by the laser beam to such an extent that the material is unable to reform the bonds when the laser excitation ceases. This opens the prospect for very rapid and complete sterilization of a wide variety of materials.

HIGH FIELD CONDUCTIVE EFFECTS IN SILICON DOPED YTTRIUM-IRON GARNET

In a program under the direction of Professor D. J. Epstein, yttrium-iron garnet, made slightly semiconducting by silicon doping, exhibits a current controlled negative resistance and a conductive memory state. The

occurrence of negative resistance and memory in single crystals offers an opportunity to study the physical mechanisms responsible for these effects in a "clean" experimental situation; such studies may help clarify analogous processes occurring in amorphous semiconductors. Moreover, the fact that these effects occur in a ferrimagnetic material may have considerable significance for device development.

LOW MOBILITY AND AMORPHOUS SEMICONDUCTORS

Professor David Adler reports that a theoretical analysis of the energy band structure of several insulating transition-metal oxides has been carried out. Electronic correlations and electron-phonon interactions have been explicitly taken into account. It was found that the oxygen 2p band is 2-4eV below the highest filled cation d levels. Nevertheless, due to electronic correlations, there is a relative shift of the 2p and d bands when impurities or non-stoichiometry are present, and extrinsic conduction still can take place in the 2p band. This analysis explains a long-standing dilemma in reconciling the localized optical spectrum and the band-like dc conductivity in these materials.

NUCLEAR MAGNETIC RESONANCE IN SOLIDS

In the work of Professor S. D. Senturia, a detailed study of the Pb^{207} Knight shift in PbTe between 4.2°K and room temperature has been completed. It was discovered that p-type material can be completely compensated by powdering, while n-type material is not affected. NMR data have been analyzed in terms of an extremely detailed energy band model of the valence and conduction bands, utilizing k.p. theory in terms of eight parameters chosen to fit the observed low-temperature values of the Knight shift, band-edge masses and g-factors, and the Shubnikov-deHaas periods and effective masses. Knight shifts of Pb^{207}, Sn^{119}, and Te^{125} have been observed in $Pb_{1-x}Sn_xTe$ samples throughout the range of lead-tin ratios. The variation of the Knight shifts with composition and carrier concentration supports the band-crossing model of Dimmock, Melngailis, and Strauss.

GLASSY MATERIALS

According to Professor D. R. Uhlmann, inclusion damage in laser glass is associated with the temperature rise of metallic particles (or the surface regions) relative to the surrounding glass. The effects on the breakdown condition of flux level and pulse time, as well as the size, shape, thermal expansivity, and spectral emissivity of the particle, and the heat capacity and thermal conductivity of particle and glass, have been specified. Sources of metallic inclusions in laser glasses and melting

technology are specified for quality control. Studies of flow behavior of liquids indicate that the theoretical models cannot describe the observed experimental data, and that free volume theories are best used to describe viscous flow at relatively high temperatures rather than in the vicinity of the glass transition.

THE STRUCTURE OF AMORPHOUS MATERIALS

Professor B. L. Averbach reports that the first results of the structure determination of amorphous As_2Se_3 have shown that the molecular groupings in the crystalline form are largely retained in the amorphous state. It appears that the structure of amorphous material with the composition As_4Se_4 is remarkably close to that of amorphous As_2Se_3, but does not appear to be related to the structure of crystalline As_4Se_4. This indicates that the electronic properties of amorphous material in this composition range may be characterized by those of the As_2Se_3 structure.

PROPERTY IMPROVEMENTS THROUGH STRUCTURE CONTROL BY RAPID QUENCHING OF LIQUID METAL DROPLETS

In joint programs under Professors Pelloux, Flemings, and Grant, it was shown by rapid quenching of relatively fine liquid metal droplets, at cooling rates 3 to 6 orders of magnitude more rapid than is possible in commercial ingot casting, that grain structures are highly refined, segregation is largely eliminated, and excess phase particles are made very fine and uniformly distributed. Resultant properties are highly improved and yield of useful alloy is greatly increased. Potential for commercialization is great.

LIGHT SCATTERING IN CRITICAL POINT PHENOMENA

Under Professor G. B. Benedek, laser light scattering experiments have resulted in the first direct measurement of the divergence of the correlation range in Xenon near its critical point. The increase in this correlation distance is perhaps the most fundamental feature of the ordering process near second order phase transitions.

In parallel studies with biological macromolecules, research has permitted the accurate measurement of the size and shape of the protein lysozyme from the spectrum of laser beams scattered by the translational and rotational Brownian movement.

ENERGY TRANSPORT IN MOLECULAR CRYSTALS

A calculation of the transport of energy via exciton motion in molecular crystals has been completed by Professor R. J. Silby. This calculation assumed linear exiton-phonon coupling as the perturbation. Using vari-

ous theoretical techniques an equation was derived of motion for the probability of energy transport. A change in mode of transport is predicted from "coherent" (wave-like) to "incoherent" (hopping) transport as the temperature is increased.

FATIGUE MECHANISMS AT ELEVATED TEMPERATURES

Professor A. S. Argon reports that a strong similarity in the development of porosity at elevated temperatures has been established between fatigue damage and neutron irradiation damage. In both cases vacancies are produced, either by dislocation intersections in cyclic straining in the case of fatigue, or by direct knock-out, in the case of neutron irradiation.

GENERAL

Four new programs granted last year by ARPA on amorphous semiconductor materials, powder metallurgy, and steerable spin waves in ferrimagnetic films have been renewed; all reported excellent research progress. Six small seed money research efforts were initiated a year ago, and have continued for a second year. Four new programs were initiated this year. It is intended to initiate similar high risk, innovative research activities, especially from among younger faculty members.

One of the special features of the Center is its support of Central Service facilities, including an extensive analytical laboratory, machine shop, four crystal growing and crystal characterization laboratories, an electron-optics facility, a laboratory for surface and interface studies and measurements, and others. These facilities are used broadly by M.I.T. staff and students, by M.I.T.-associated laboratories and centers, and by outside groups (industry, hospitals, other universities, and the police, for special needs). It is intended to maintain these facilities with the best instrumental and analytical equipment available. In this respect, an ARPA grant of $400,000 last year permitted major additions to facilities plus important upgrading of others.

NICHOLAS J. GRANT

CENTER FOR SPACE RESEARCH

Studies and experiments have been continued over the past year in the Center for Space Research in the general field of space science and engineering, involving projects under the supervision of approximately 20 faculty members from the Departments of Physics, Earth and Planetary Sciences, Aeronautics and Astronautics, and Electrical Engineering. This research has been supported by the efforts of approximately 50 full-

time research staff, and 50 hourly and biweekly personnel. About 30 students have been directly involved under research assistantships and 15 to 20 more on part-time employment.

In the 1969-70 report from the Center, the specific objectives and programs of the several ongoing and proposed space flight experiments were described in some depth. Significant developments in these programs are highlighted below.

1. The Interplanetary Monitoring Platform (IMP) program under the supervision of Professor Herbert S. Bridge is continuing generally as planned. Launch has been delayed for the H and J spacecraft, respectively, to 1972 and 1973.
2. The Orbiting Solar Observatory (OSO) program under the supervision of Professor George W. Clark is also continuing as planned with the launching of this spacecraft now scheduled for October, 1971.
3. The Small Astronomy Satellite (SAS) flight hardware contract has been received and this program will see a major expansion of effort in the Center as the design and fabrication of the payload evolves. The prospective launch date of this payload is 1973. The principal investigator for the SAS program is Professor George W. Clark.
4. The x-ray astronomy experiments from sounding rockets under the supervision of Professor Hale V. Bradt posted its sixth successful launch in May 1971. Important new x-ray pulsation data and precise locations of several sources were obtained.
5. The x-ray astronomy experiments from high altitude balloons, under the supervision of Professor Walter H. G. Lewin, made two successful flights from Australian launch sites. Important new data on the flaring characteristics of sources GX 304-1 and GX 301-2 were obtained as well as the discovery of two new variable sources (GX 301-2 and GX 1 and 4.) Three new Australian flights have been proposed for launch in early 1972.

Successful proposals have led to the assurance of several new projects in space flight experimentation to be undertaken at the Center. The Mariner Venus-Mercury mission, which will study the plasma regime at the planet Mercury and the interaction of the planet Venus with the solar wind, has been placed under a definitive contract between M.I.T. and the Jet Propulsion Laboratory. Launch of this spacecraft is scheduled for October, 1973. This research is under the supervision of Professor Herbert S. Bridge. The design and construction of a two-crystal spectrometer for use in the x-ray spectroscopy experiments to be carried out aboard the Astronomical Netherlands Satellite experiment will be undertaken by Professor H. W. Schnopper over the period through December, 1972. The Office of Space Sciences and Applications of NASA has selected

Professors Hale V. Bradt and Walter H. G. Lewin as two of the principal investigators for the first High Energy Astronomy Observatory mission due for launch in 1975. The work will include the design of the integrated x-ray modulation collimator experiment to determine the positions of celestial x-ray sources to about 5 arc-second accuracy as well as angular size to about 5 to 10 arc-seconds in eight energy bands from 0.18 to 20 Kev. (Bradt); and the determination of the position and intensity of extragalactic x-ray sources over an energy range from 10 to 150 Kev (Lewin).

In addition to the program in experimental astrophysics summarized above, the center carries on a significant research program in astrophysical theory which is supported by grants from NASA and NSE. These researches under Professors Philip Morrison, Icko Iben, Jr., and William K. Rose, are discussed in the report of the Department of Physics.

The Lunar Surface Electrical Properties experiment, under the supervision of Professors G. Simmons and J. V. Harrington, is proceeding on schedule as a major program of the Center. The Raytheon Co., Equipment Development Laboratories, in Sudbury, Massachusetts, has a major subcontract from M.I.T. to carry out the detail design and fabrication of the prototype and flight equipment. Management of the program is being provided by Dr. James W. Meyer, on leave from the Lincoln Laboratory. Engineering support is being provided by the Center's Laboratory for Space Experiments and by the Draper Laboratory. Preliminary field trials of the field evaluation model of the experimental equipment will start in early July, 1971, on the Athabasca Glacier near Calgary, Canada. The lunar experiment equipment will be transported to the lunar surface aboard Apollo 17.

NASA is supporting an interdisciplinary study of domestic information networks user requirements, under the supervision of Professor John V. Harrington, which includes specialized areas of research and inquiry leading to an assessment of the domestic communications systems growth potential over the next 20 to 30 year period. Professors John P. Ruina and Robert S. Kennedy of the Department of Electrical Engineering, and Professors George W. Rathjens and Ithiel D. Pool of the Department of Political Science are assisting in specialized areas of research and inquiry leading to an assessment of the domestic communications systems growth potential over the next 20 to 30 year.

Primarily as the result of several recent and successful proposals to NASA for space flight programs, the total volume of research in the Center is expected to show a significant increase in the 1971-73 period. The total volume for the 1970-71 year was approximately $4.5 million, representing a $2 million increase over the previous year; about 60 per

cent of which is directly attributable to the major industrial subcontract under the lunar Surface Electrical Properties experiment. The total volume of research is expected to show a continuing increase over the coming year, concentrated largely in space flight experiments for the study of celestial x-ray sources and interplanetary plasmas.

JOHN V. HARRINGTON

EDUCATION RESEARCH CENTER

This year at the Education Research Center both the scope and level of effort in educational reform and curriculum development were expanded. Many projects moved beyond the inception and development stages and began the equally difficult processes of proliferation and adaptation into a variety of academic settings. The tight funding situation, with which we began the year, was substantially eased by major grants from the Carnegie Corporation of New York and the National Science Foundation. Major projects included:

FILM IN THE STUDY OF HUMAN BEHAVIOR Although young people are comfortable with film as an entertainment medium, few imaginative attempts have been made to apply the versatility of film to education. E.R.C. staff members are currently developing curricula in both law and anthropology which rely heavily on the presentation of filmed material in the classroom. In addition, a technical team has nearly completed work on the design of a low-cost, light-weight, synchronous-sound Super-8mm film system which will make film as a new mode of data gathering and reporting, accessible to students generally.

GRADUATE STUDY FOR COLLEGE TEACHING Supported by a grant from the Carnegie Corporation of New York, an E.R.C. team has begun development of an interdepartmental Ph.D. program for students interested in careers in college teaching, combining professional certification in a discipline with a supervised teaching internship and work in education research or other interdisciplinary areas.

LABORATORY, COMPUTER, AND CALCULUS-BASED COURSE IN MATHEMATICS This project is an approach to mathematics consciously minimizing the abstractions of conventional subjects and enabling the student to discover the utility of algebra, trigonometry, and geometry as tools for solving real problems. Learning materials are being developed which combine the intuitive nature of the fundamental concepts of calculus

with practical experience in measuring and analyzing natural systems by the integration of laboratory experiences. The National Science Foundation has provided funding to stimulate further development and compilation of this material into an integrated course of study.

PHYSICS CURRICULUM PROJECT The physics curriculum project marked the culmination of its initial decade with the publication of two more texts, *Mechanics* and *Vibrations and Waves*. Future volumes on electricity and magnetism and quantum physics will complete *The M.I.T. Introductory Physics Series* that includes also background documentation, filmed demonstrations, and laboratory learning aids.

SELF-PACED STUDY The self-paced, mastery-oriented, tutor-assisted method of organizing a course, sometimes called the Keller Plan, has stimulated a significant change in the process of undergraduate education at M.I.T. by freeing many students from lock-step learning. Through the Center, half a dozen subjects were taught in the self-paced mode during the past year, and the total undergraduate enrollment was nearly 500. Self-paced subjects in the regular curriculum now exist in mathematics, civil engineering, physics, and chemistry. The Center has received funding to assist in disseminating the Keller Plan beyond M.I.T. and sponsored a summer workshop in self-paced learning attended by 20 college teachers.

UNDERGADUATE RESEARCH OPPORTUNITIES The main goal of the Undergraduate Research Opportunities Program (U.R.O.P.) is to involve students directly in the actual research work of the faculty. On a mutually agreed-upon basis, and with the support services from U.R.O.P. staff, the undergraduate enters into the professional activities of a faculty member or research team as a junior but contributing member. Student participants in the program receive regular academic credit for their work. More than 300 undergraduates were registered in U.R.O.P. each term during the academic year.

UNIFIED SCIENCE STUDY PROGRAM The past year saw the Unified Science Study Program complete its second year of offering a multidisciplinary program which relies on student initiative rather than the traditional sanctions of requirements, prerequisites, examinations and grades. During the year, U.S.S.P. provided full-time involvement for 75 freshmen and sophomores from M.I.T., North Shore Community College, the University of Massachusetts at Boston, and the Boston Model Cities Higher Education Program.

U.S.S.P. is conceived to be one model of education reform, emphasizing a project-oriented style of learning, with national applicability. This past year Tufts University, which had a small contingent of students and faculty at M.I.T. during the first year of U.S.S.P., began a similar program on its own campus. Major grants from the Carnegie Corporation of New York and the Esso Education Foundation now support activities to initiate the development of U.S.S.P. at other institutions.

JERROLD R. ZACHARIAS

ENVIRONMENTAL RESEARCH AND EDUCATION

While much research at M.I.T. has concerned itself with the conditions of the physical world, within the past two years a more concerted effort has been made to relate the research activities to one another and to the physical and social environment. There have been essentially three major efforts in marshalling research and academic resources for more systematic study of the environment.

The first of these efforts was the appointment in early 1970 by President Howard Johnson of a Task Force on the Environmental Quality chaired by Professor Raymond Baddour. This student-faculty group made several recommendations, the first of which was the creation of an Environmental Laboratory designed to be interdisciplinary. The Lab has undertaken an effort to define appropriate environmetal research topics. During its early months it has sponsored an energy study by Professors Hottel and Howard and has sponsored Professor Carroll Wilson's summer study for the United Nations environmental conference in Stockholm.

In February, 1971, President Johnson appointed an Interdisciplinary Environmental Council (I.E.C.) consisting of faculty and students. The Council is charged with locating resources to assist in interdisciplinary research efforts, and stimulating environmental undergraduate and graduate studies primarily of an interdisciplinary nature.

Under the aegis of the Interdisciplinary Environmental Council, faculty are beginning to report on disciplinary and interdisciplinary research projects in the following areas:

NOISE POLLUTION A set of projects studying engine noise, air craft noise, urban noise due to V/STOL aircraft, and systems study of noise requirements. These projects are primarily carried on by the Department of Aeronautics and Astronautics and the Department of Mechanical Engineering.

ATMOSPHERIC POLLUTION This consists of a number of departmental projects in Mechanical Engineering, Chemistry, Chemical Engineering, Metallurgy, and Aeronautics and Astronautics. Some of the faculty involved in these projects are also on the I.E.C.

WATER QUALITY CONTROL Under the direction of Professor Eagleson, faculty working on water quality problems are meeting to discuss cooperative research and educational projects.

A STUDY OF MASSACHUSETTS BAY Supported by the M.I.T. Sea Grant Program, the study is under the leadership of Professors Ippen and Mollo-Christensen. The 1971 summer work has cooperated with a number of other Boston Harbor studies and will lead to a three-year study covering such areas as mariculture, waste disposal, pollution management, transportation systems, coastal zone development.

INTERNATIONAL COOPERATION IN THE ENVIRONMENTAL FIELD Professors Skolnikoff and Baram are producing a report in this field.

A NEW ENGLAND REGIONAL STUDY Dean Keil, and Professors Seifert and Fay have submitted a proposal to the National Science Foundation for a New England regional study in which NSF is deeply interested. Discussions are still underway with the NSF.

Under the sponsorship of the I.E.C. each department has appointed an environmental advisor to work with students, both undergraduate and graduate, who are interested in concentrating in environmental studies. A subcommittee of the I.E.C. has undertaken responsibility for publishing information on environmental studies for student use and for investigating the feasibility of further environmental education developments.

There is no environmental engineering major at M.I.T., although the Department of Civil Engineering this September has approved an environmental engineering concentration among the offerings for undergraduates. It is expected that other departments will also develop intra- and interdisciplinary majors.

The Environmental Laboratory reports to the President and is assisted by a policy advisory committee. The Interdisciplinary Environmental Council consisting of faculty and graduate and undergraduate students is chaired by the Provost. The Office of the Provost acts as a clearinghouse for information on educational developments in the environmental field. Professor David Wilson of Mechanical Engineering is serving as an advisor to the Physical Plant on M.I.T's own ecological posture.

LOUIS MENAND

HARVARD-M.I.T. PROGRAM IN HEALTH SCIENCES AND TECHNOLOGY

During this year significant progress was made in the detailed planning, development, and implementation of programs. Many opportunities for joint activities as well as some of the practical organizational and fiscal problems of creating a joint enterprise between the two universities were explored in depth. As a result of these explorations, the need for and the desire to engage in a major collaborative effort emerged more strongly than ever.

Initial educational efforts were focused on developing curricula in human biology which qualify the student to enter the clinical years of medical school and curricula in bioengineering. A major step in the Program's evolution was the admission into the Program of 25 graduates of M.I.T., Harvard College, and Radcliffe College as candidates for the M.D. degree at Harvard Medical School. Upon satisfactory completion of a curriculum in human biology, these students will be admitted to the clinical years of study. After this first year, an increasing proportion of the students will be enrolled in the M.D. program at an earlier period in their college careers and may be able to complete their studies sooner than the normal eight-year period. A special admissions committee, composed of faculty members drawn from M.I.T., Harvard Medical School, Harvard College, and Radcliffe College was formed to screen applicants.

New human biology subjects under development for presentation in 1971-72 included: Functional Anatomy of Man, Human Pathology, Cardiovascular Pathophysiology, Endocrinology, Gastroenterology, Hematology, Bone, Connective Tissue and Skin, and Reproductive Physiology and Human Sexuality.

These subjects are designed to achieve progressive penetration of engineering and the physical sciences into biology and medicine and will be taught jointly by biological scientists, physicians, physical scientists, and engineers. All subjects will be presented in a term pattern that conforms to the schedules of both universities. This will permit students to enroll in other subjects taught at M.I.T. and Harvard University. Time is allotted for elective subjects and therefore, it is possible for students enrolled in the Program to study for the M.D. degree and to pursue simultaneously further study in areas of their interest.

In bioengineering, interinstitutional programs are under development for engineers who wish to work at the interfaces of engineering and biology and medicine, or in a clinical setting, and for physicians who wish to learn those parts of engineering that fit their needs and interests.

Ten new subjects were developed and presented during the past year. For the long term, a spectrum of academic programs is planned, ranging from basic subjects in physiology, mechanics, materials, and flow, to subjects in the development of new medical and biological techniques. Other subjects will be concerned with the analysis, evaluation, and design of systems for the delivery of health services.

Research and development activities focused on an interinstitutional, interdisciplinary program in biomaterials science. A collaborative program of 18 research projects involving 38 faculty members of both M.I.T. and Harvard evolved from a series of seminars. The faculty members include physicians, surgeons, biochemists, biophysicists, physical chemists, physicists, and chemical, electrical, and mechanical engineers. A request for support of the research program was submitted to the National Institutes of Health with Professor Robert W. Mann as the principal investigator.

Important developments occurred in the administration of the Program. The universities agreed on the general administrative organization, the scope of the Program, the resources required, and the procedures for fund raising and for allocation of resources. Several committees were formed to guide the evolution of the Program.

A major fund-raising program was initiated to meet the cost of the proposed undertaking and to provide the financial base necessary. Dr. Walter L. Koltun was appointed Assistant Director for Resources to coordinate efforts. A target of $10 million was established as the minimum endowment necessary to sustain the Program and to support a major fraction of the needed core senior faculty. A member of the Corporation has contributed $1 million to the Institute toward support of the Program. A request for continued support for the development and implementation of the educational programs for 1971-72 was submitted to the Commonwealth Fund.

There were additional efforts oriented toward expanding health-related activities at the Institute. Initial steps were taken to establish a Division of Health Sciences and Technology which the faculty Committee on Health Sciences and Technology recommended to the faculty at its April 21, 1971, meeting.

In the area of Health Planning and Management a committee was organized to develop programs of education and research.

A task force was established to study the development of a comprehensive health care program for the M.I.T. community. Its report and recommendations should be submitted by the end of 1971.

IRVING M. LONDON
LANG WALTER KOLTUN

INFORMATION PROCESSING SERVICES

During the past year, the Information Processing Services organization has devoted major efforts to reducing costs while maintaining momentum for growth in the scope and quality of the information processing services provided to the community. At the close of the year, the Institute's expenditures for the provision of these information processing services were in excess of $6 million, or approximately 6 per cent of the Institute's total on-campus budget. This total excludes most of the cost of the many substantive programs of research and instruction at M.I.T. that are heavily involved with computing. It includes only those costs directly associated with providing information processing services to these programs.

Administration of the Institute's planning activities and facilities operation in the information processing services area is divided into four sections, namely central computer services as provided by the Information Processing Center; administrative systems development and operation; departmental computer services; and research equipment, each of which is discussed below. Assisting with the administration of these activities is the Information Processing Advisory Committee which continued during the year to provide both sound advice and strong support for development of computing activities at M.I.T.

INFORMATION PROCESSING CENTER

The Information Processing Center is the source of approximately two-thirds of the computer service utilized in the M.I.T. community. During the year, the I.P.C. operated four major computer systems through a staff of 45 professional employees, 55 computer operators, and 20 clerical, secretarial, and support personnel.

A major area of activity for the Center during the year resulted from the unusually rapid redirection of emphasis of the community of computer users from batch processing towards time-sharing. This redirection was due to a combination of factors including decreasing cost differentials for time-sharing, the greater user-orientation present in the design of such systems, the greatly enhanced ability of users of time-sharing to exchange work with each other and to build and use tools, and the clear appropriateness of this type of service to the instructional and research communities.

In December, 1969, less than half of the utilization of the Information Processing Center was through time-sharing services. However, by June, 1971, this fraction had risen to over two-thirds. While long-predicted and actively promoted by the Information Processing Center, this change

was more rapid during the past year than had been anticipated. A direct result has been that batch processing facilities provided by the Center are not fully utilized and, particularly during peak times in the academic year, time-sharing facilities are heavily overloaded. Consequently, planning by the Center during the year was directed at the expansion of time-sharing services through equipment and software changes and at the reduction of batch processing costs through establishment of a cooperative facility jointly with Harvard University.

A further step in the development of the organization of the Information Processing Center was taken towards the end of the year to increase the emphasis on improving the interface between the user community and the services provided. In this reorganization, a new Computer Services Division was created under the direction of Mr. Joseph R. Steinberg, Assistant Director of the Center. This division is responsible for operations, application programming, technical services, and user information; it will serve as the contact point between the Center and the informal I.P.C. Users' Committee. The remaining two divisions, namely Systems Programming and Planning and Administration, are concerned more directly with the provision of computer service than with its use. The two functions of systems development and systems maintenance and assurance are conducted within the Systems Programming Section while the Planning and Administration Section is responsible for internal administration of the Center, user accounting and the coordination of planning activities.

The major computer services offered by the I.P.C. are:

BATCH SERVICES

These services continued to be supplied on a System/360, Model 65 and System/360, Model 40 computer complex operating under OS/MVT-ASP. Typical monthly operations now include 18,000 jobs, with between 10 per cent and 20 per cent submitted through remote-job-entry terminals; 9 million cards read; 1 million cards punched; 25 million lines printed; and 4,500 tapes or disks mounted for users. In the fall of 1971, this system will be replaced by a System/370, Model 155-Model 145 complex to serve the combined needs of the Harvard University and M.I.T. user communities. The batch service provides an environment with extensive applications software oriented primarily towards the natural and social science communities.

TIME-SHARING

1. MULTICS — The Multiplexed Information and Computing Service (MULTICS), operating on the large Honeywell 645 computer configura-

tion, continues in its second year as the Institute's main time-sharing system. During the year, hardware and software improvements have allowed expansion in the maximum number of simultaneously logged-in users from 25 to 56; and the number, sophistication and richness of the set of commands, software packages, and subroutines available to users has grown significantly. Utilization of this system more than doubled during the year and typical monthly load now involves 14,000 logins and 14,000 console hours of work. A major activity is currently underway to develop firm schedules for the delivery of new hardware to operate this service at greater capacity and at significantly decreased unit cost. It is currently expected that such hardware will be delivered in mid-1972 and become the standard service facility for the MULTICS system in January, 1973.

2. CP/67-CMS — Use of the IBM System/360, Model 67 computer grew significantly during the year. This system now serves between 25 and 30 simultaneous users from over 100 projects. Typical monthly load involves 7000 logins and 5000 console hours of work. The community of users associated with this service is diverse and includes those who require remote access to a System/360, those who are developing operating systems using the virtual machine concept, and those doing general utility time-sharing.

3. CTSS — The Compatible Time-Sharing System (CTSS) operates on a highly-modified IBM 7094 computer and served as the Institute's primary time-sharing system during the middle and late 1960's. During the year, the decision was formally taken to discontinue this service on June 30, 1972. New use of CTSS is no longer permitted, and efforts are underway to convert the few remaining users to other environments. Use of CTSS at the end of the year stood at less than 40 per cent of its level of use one year earlier.

ADMINISTRATIVE SYSTEMS

During the year major progress was made in unifying the Institute's administrative data processing facilities and services. Administrative computer services have previously been provided by two separate groups. The Comptroller's Data Processing Office served the computing needs of the Institute's financial administration while the Office of Administrative Systems provided systems development, maintenance and operation for the non-financial administrative functions. In the summer of 1971, a new office, to be known as the Office of Administrative Information Systems (O.A.I.S.), will be established through the combination of these

two offices. This new office will be responsible not only for operating and improving the current administrative systems of the Institute but, in addition, for producing and implementing a coordinated plan for the development of administrative information systems at M.I.T.

DEPARTMENTAL FACILITIES

Supplementing the information processing services provided by the I.P.C. and the O.A.I.S. are services provided through eight other computer centers operated for academic departments or research laboratories in order to serve somewhat specialized instructional and research requirements. These include the TX-0 and PDP-1 facility that serves computer research needs in the Department of Electrical Engineering and the Research Laboratory for Electronics; four IBM 1130 facilities that provide general computing service for the Departments of Civil Engineering, Mechanical Engineering, Chemical Engineering, and the Center for Advanced Engineering Study; a System/360, Model 65 facility serving the Laboratory for Nuclear Science; a PDP-6/PDP-10 installation serving the Dynamic Modeling Group at Project MAC; and a second PDP-6/PDP-10 installation serving the Artificial Intelligence Laboratory. No major changes were made in any of these facilities during the year.

One facility, an IBM 1130 that served the Sloan School of Management and the Department of Economics, was removed during the year and replaced by a branch office of the Information Processing Center. It is expected that future reductions in the cost of computing equipment will make it possible for other small computer facilities to be replaced by access to a central computer with net cost reductions and with increases in the services available.

RESEARCH EQUIPMENT

A large number of academic departments and research laboratories have acquired computers ranging from the extremely small to the medium-sized for use with particular experiments. These facilities, while clearly general purpose digital computers, are not counted amongst the service facilities of the Institute since they provide essentially one type of service for a fairly restricted community. The number of acquisitions of this type made during the past year was much smaller than in previous years, primarily as a reflection of the changing patterns in research funding.

THE FUTURE

During 1971-72 the major activities for the Information Processing Services Office will be the formal establishment of the joint batch

processing facility with Harvard University, completion and implementation of plans for the extension of MULTICS to new hardware, final removal of CTSS from the campus, consolidation of the majority of M.I.T.'s administrative computing into a single environment, development of a coordinated administrative systems development plan for the Institute, improvement in the ease and efficiency with which the administrative interface is conducted with users, completion of a personnel evaluation and classification scheme to facilitate promotion and transfer of the more than 150 members of M.I.T.'s research and administrative staffs who serve as programmers, and continuous — hopefully dramatic — improvement in the ways in which we are able to help members of the community to utilize computer service.

Planning studies initiated during the past year that will be continued are aimed at analyzing and understanding the computing community, measuring requirements for computer services, and making trade-offs between various requirements for service. These studies, it is expected, will lead to the publishing of several papers on the management of computer service facilities.

ROBERT H. SCOTT

INNOVATION AND REFORM IN UNDERGRADUATE EDUCATION

During this year the Land Education Development Fund has continued to serve as an important stimulus to the development and implementation of new alternatives in undergraduate education. Two large-scale programs which began in 1969 with Land Fund support have continued for a second year, with participation from sophomores as well as freshmen. These programs, which supplant the normal program comprised of independent subjects, and which put special emphasis on student self-direction and on new modes of student-faculty interaction are: the Experimental Study Group, under the leadership of Professor George E. Valley, Jr.; and the Unified Science Study Program, under the leadership of Professor Jerrold R. Zacharias and Dr. Judah L. Schwartz.

These programs will continue for a third year, during which their effectiveness will be assessed by the Committee on Educational Policy. It seems likely that the experience gained in these experimental programs will lead to the introduction of new alternatives in the future.

The first-year core subjects in physics, chemistry, mathematics, and humanities are now offered in several alternative forms which provide considerable ranges of choice in both content and style. The introduction of self-paced study, with a very flexible pattern of subject organization,

and the use of standardized examinations as measures of accomplishment, have permitted individuals to proceed at rates best suited to their own preparation and desires. The lecture-recitation mode of instruction has decreased in importance as a vehicle for first-year instruction.

The Undergraduate Research Opportunities Program, which is under the direction of Professor Margaret L. A. MacVicar, has expanded in terms of both student and faculty participation. This program, which encourages informal and close association between undergraduates and faculty members through collaboration on problems of common interest, provides an important complement to the Freshman Seminar Program, which has been active for more than a decade. Both build on a fundamental and distinctive strength of the Institute, which is the broad range and vitality of the intellectual activities of the faculty. For many undergraduates, these programs provide an important and central component of their academic programs.

In the same pattern as in recent years, albeit at somewhat reduced levels, curriculum development funds have been made available to the departments for the support of revision and innovation in upperclass programs and subjects. These centrally-administered funds constitute a particularly important resource as departmental budgets have tightened during the past two years.

PAUL E. GRAY

JOINT CENTER FOR URBAN STUDIES

The Joint Center passed through a period of change during 1970-71. In December 1970, the association with the Ford Foundation, which had maintained primary responsibility for the funding of the Center, finally came to an end after twelve fruitful years. Since the Center's founding in 1959, the commitment to urban studies as a legitimate area of teaching and research at Harvard and M.I.T. had grown immeasurably, for which the Center could claim considerable credit. Yet this had led to the realization that the purposes of the Center, which had originally been to support and encourage urban studies at the two universities, might now profitably be revised to meet the needs of the seventies. During 1970-71, therefore, a reassessment was made of the current goals of the Center, and new ones were formulated. It was determined that the resources of the Center could best be exploited by concentration on a few key areas of study rather than on a wide range as had been the case in the past. Housing in the United States emerged as one such area while proposals were drawn up to pinpoint other crucial issues for study and to elicit significant new sources of funding.

Dr. Robert C. Wood resigned as Director of the Center during the summer of 1970 to assume the position of President of the University of Massachusetts, and Dr. Walter A. Rosenblith, then Associate Provost of M.I.T., became acting director of the Center during the period of reassessment. Once housing had been chosen as the primary focus for the future research program of the Center, efforts were made to select a new director. Toward the end of the academic year, the appointment was confirmed of Bernard J. Frieden, Professor of City Planning at M.I.T., to take over direction on July 1, 1971.

The Joint Center functioned at a reduced level of research support during 1970-71, maintaining a small number of research projects. The major projects were Professor Lee Rainwater's extensive study of family behavior and social policy, Daniel H. Fenn's analysis of corporate involvement in, and contribution to, the Boston metropolitan area, Herbert Gans' analysis of the way in which the news is shaped by the national media, and a series of workshops on juvenile delinquency under the general direction of Professor Charles Haar of the Harvard Law School. The Survey Research Program continued to provide research support for the Joint Center, and for other outside studies. The Joint Center's fellowship program was maintained, and ten fellowships awarded to graduate students at M.I.T. and Harvard who were writing dissertations in the area of urban studies. One of the fellowships marked a departure from earlier practice: it was awarded by WCBS-TV, and was made contingent upon the winner working part-time for the television station in New York.

The Joint Center issued three reports during the year:

How the People See Their City: Boston 1969, a report of the Survey Research Program of the Joint Center, and representing the findings of a survey of the Boston population to discover their attitudes to housing costs, city services, and other matters of public concern;

The Boston Rehabilitation Program, an analysis by Langley Keyes of a major rehabilitation effort conducted on a crash basis in the Roxbury section of Boston during 1968-69;

The Role of University Based Urban Centers, a report of the conference held at Endicott House in June, 1970, to mark the tenth anniversary of the founding of the Center.

BERNARD J. FRIEDEN

LABORATORY FOR NUCLEAR SCIENCE

At the Laboratory for Nuclear Science, programs in nuclear and elementary particle physics research, both experimental and theoretical, were

conducted over a wide and vigorous front, though on a necessarily smaller scale than previously because of substantial budget cuts. This situation reflected the government's heavy cut in the funding of basic physics research, particularly as supported by the Atomic Energy Commission. The Laboratory has had to streamline every project to a fraction of both the potential research capability of the group involved and the scope of previous years. Restricted funds have also affected the level of student support which the Laboratory can provide. Last year we admitted no new graduate students with L.N.S. assistantships. For the 1971-72 academic year we have admitted only a few. We will be supporting about 440 man-months of student effort next year, compared to 650 in 1968. It is our hope over the next few years to restore the number of graduate assistants to better levels.

Besides work in nuclear and elementary particle theory, research last year involved low energy experimental studies of a range of nuclear reactions induced both by accelerated charged particles and by radioactive source techniques. Because of financial stringency it was necessary for the Laboratory to terminate work of its 8 MeV ONR Van de Graaff accelerator. The efforts of the group working with that accelerator will instead now center around the application of the Brookhaven double tandem accelerator, in collaboration with staff of that facility. Several experiments have already been carried out at that accelerator during the past year.

In so-called "intermediate energy" nuclear physics, the work of Professors Barber, Bertozzi, Demos, and Kowalski with Drs. Sargent, Turchinetz, et al., has continued in preparation for the electron scattering program projected for the L.N.S. 400 MeV electron linac being built at Middleton, Massachusetts. This year the activity has been focused upon procurement of the large energy-loss spectrometer designed for use with the linac. Construction of the linear accelerator itself is proceeding well, in the light of the limited funds available. The future schedule is for completed physical construction of the machine and beginning of beam tune-up by late 1972 or early 1973.

In L.N.S.' program for experimental elementary particle ("high energy") physics we may highlight:

1. The LNS-SLAC (Stanford Linear Accelerator) collaboration, involving Professors Friedman and Kendall, whose electron scattering studies with that machine have led to a possible interpretation that protons have small charged objects within them. Such a substructure in the hadrons has been interpreted as evidence for quarks or "partons."
2. Detailed studies of the L.N.S. groups at C.E.A. (Professors Deutsch, Frisch, Osborne, and Luckey), at DESY Synchrotron in Hamburg, Ger-

many (Professor Ting et al.), and at the Stanford Linear Accelerator (Professors Osborne, Lanza and Luckey). These studies, among other things, relate to the "vector-dominance" theory, which identifies photons as members of a larger family of particles including the rho, omega, and phi mesons. The more straightforward of the experiments confirm vector dominance, while the more subtle tests seem to cast doubt on the simple form of the theory.

3. An experiment is currently being set up at the Brookhaven Alternating Gradient synchrotron using the new 4π solid angle gamma-ray detecting spark chamber system to study antiproton-proton annihilations leading to totally neutral final state particles. This technique offers a new method for the search for heavy boson resonances, and the determination of their quantum numbers.

4. PEPR, the automatic film scanning device developed in L.N.S. for the analysis of bubble chamber photographs, has reached a highly successful operating stage. It gives record precision and is able to measure more than 200 Bubble Chamber events per hour. With this capability, the accuracy and speed exists for study of multi-particle production reactions in elementary particle collisions, and the efforts of those associated with this work (Professors Feld, Hulsizer, Pless, Yamamoto, Dr. V. Kistiakowsky, et al.) are being concentrated on the separation of the various reactions and the interpretation of their dynamics. A major study is under way of $\pi\pm$ meson-proton collisions over the range of 4 to 16 billion electron volts. It is becoming clear that the possible reactions break up into two classes: one in which the reaction appears to be caused by the exchange of one or more familiar particles; and a second in which the interaction appears to be caused, without such exchange, through what is now called the diffraction-dissociation process.

Two recent exciting developments in particle accelerators continue to give major stimulus to high energy research in L.N.S. The first is the building of a colliding electron-position facility at C.E.A. Two of the three L.N.S. groups that have worked at C.E.A. have joined together to develop a large solid angle magnetic detector for use around the interaction zone of the colliding beams. The second accelerator development is the plan for completion of the National Accelerator at Batavia, Illinois, by the end of 1971, and for operating it at very high energies (up to 500 billion electron volts) perhaps by mid-1972. Three of our high energy groups are actively involved in preparing for research at this accelerator.

PETER T. DEMOS

LIBRARIES

The end of the past year is a particularly good time to take a look at the Libraries because it is a turning point. Many of the factors which have influenced developments over the last 15 years have recently altered. Chief among these is the levelling off of the invigorating flow of money. Like the rest of the Institute, the Libraries started over a year ago to switch to a deflationary economy. But even if there were money enough to compensate for inflation, to buy books in new fields, and to keep abreast of the world's 10 per cent a year rise in publications, there are other factors which should be studied as we enter the seventies. Mainly, these are questions about what kind of libraries M.I.T. should have to support teaching and research and how decisions should be made.

THE FUTURE

The most important development of the past year for the future of the Libraries is the appointment by President Howard W. Johnson of an Ad Hoc Committee to review the Library system of the Institute. His Charge to Dr. Robert A. Alberty, Dean of the School of Science, and to the Committee reads in part:

> The rapidly growing and changing needs of the students and faculty for access to literature and to bibliographic and information services, together with increasing financial pressure on all programs at the Institute, make it desirable that a new study of the library system of the Institute be undertaken by an Ad Hoc Committee, of which I would like you to be Chairman. The following points need to be considered:
> 1. The Committee should seek to delineate an array of alternative short- and long-range policies and their instructional and research implications, as well as the effect these policies might have on the evolution of the libraries. This should include recommendations concerning the framework for the management of the library system and recommendations with respect to sources of financing. Obviously the financial pressures upon the Institute represent one of the most important constraints of the library system in the years to come.
> 2. The Committee should indicate which functions of the library system are most important to the Institute community and which require less emphasis. To what extent should the organization of the libraries continue to parallel the Institute's departmental structure? Should there be changes in the coordination of libraries on the M.I.T. campus? To what extent should the libraries be innovative and engage in research? What should be the role of new technologies, particularly the techniques of information processing, in our library system? To what extent should our library system include information other than bibliographic, such as data and graphic material? How can cooperation with other libraries and information sources in regional or national networks help our libraries meet their goals?

The Committee is representative of a number of different faculty points of view and includes a graduate student and an undergraduate. They have already begun to work and hope to be able to report before the

end of the calendar year. Their recommendations can be expected to determine the direction the Libraries will take in the next decade.

The Committee will have to face up to some hard decisions growing out of the rapid evolution of M.I.T. into a university, as evinced by the faculty vote this year in favor of departmental status for Philosophy. No one at M.I.T. would accept the idea of becoming a second-rate university, but a first-rate university must have first-rate libraries. Ours are not first-rate now and financial stringencies point in the direction of a decrease rather than an increase in quality. As a compromise we may have to settle for some areas of excellence and some collections that are merely good.

Shortage of money also indicates the desirability of developing a book selection policy for each library which will indicate its areas and levels of collecting. This could economize as much as $50,000 a year by avoiding unnecessary duplication. The Dewey and Rotch Libraries are a quarter of a mile apart. They deal with verbal disciplines, as does Humanities, which is half way between them. For efficient library service to the community in the coming years, all three should be combined in one building, as recommended by the Sherwood Committee on Long-Range Planning for the Libraries ten years ago.

In the 20 years since the construction of the Hayden Building, the centralization-decentralization pendulum has swung in the direction of more and more departmental libraries and reading rooms. They are especially attractive to the faculty as they undoubtedly give more personal service but the costs of maintaining them should be recognized: $20-30,000 a year for a branch cannot be spent building collections in new areas.

The question of how policy decisions concerning the Libraries are to be made on a continuing basis is an important one. Traditionally, it is the Faculty Library Committee which provides policy guidance to the Director of the Libraries, but the biggest users of the Libraries — and those who suffer most when they are inadequate — are graduate students. They are underrepresented in policy making. On the Ad Hoc Committee there are, to be sure, one graduate student and one undergraduate. On the Executive Board of the Faculty Committee on the Libraries this year there were six faculty members, one graduate student (except for the last two months when a second joined us), two undergraduates, and three members of the Library staff, but only the faculty members and two librarians can vote.

In different years the Executive Board's activity has tended to vary from all to none as a function of the interest of the Chairman. This year it was exceptionally active, meeting biweekly under the Chairmanship

of Professor Gene M. Brown of Biology to discuss operations with the professional staff. Thus, it laid the groundwork for the Ad Hoc Committee mentioned above. Also active was the Corporation Visiting Committee, Philip H. Peters '37, Chairman, which discussed in detail the problems and successes of each of the 15 Library departments and will make a number of recommendations to the Corporation.

With the evolution of the university into a more democratic society, perhaps the time has come for better representation in deciding policy for the Libraries. Studies by Raffel and Shishko (*Systematic Analysis of University Libraries: An Application of Cost-Benefit Analysis to the M.I.T. Libraries,* M.I.T. Press, 1969, pp. 63-65) have shown that undergraduates, graduate students, and faculty and research staff want different things from the Libraries. Obviously these preferences should be taken into account in policy making. Perhaps the time has come to substitute an Institute Library Committee for the Faculty Committee on the Libraries.

THE PAST

In writing his Annual Report the Director of Libraries has the benefit of the Annual Reports of the heads of the individual Libraries and Library Departments, which are on deposit in the Institute Archives. There is space here to touch only on the most important points of the year's operations.

We see a continuing annual growth of 10 per cent in the number of books and serials ordered and with no new staff in Technical Services we are faced with growing backlogs. The most serious situation is in the Serials and Journals Department, newly created and never adequately staffed. Inability to cope with the constantly increasing workload in Technical Services causes morale problems there and unhappiness in the individual libraries where the librarians, whose own staff has been reduced, have to face criticisms of the public over the deterioration of service. Meanwhile use is heavy. Loans are up 13 per cent; missing books are up; and more people are failing to get books back on time.

Lack of space is another painful reality in Technical Services and in Dewey and Rotch. In spite of the addition of two classrooms to our book storage space in Dewey, we are hardly better off than a year ago because the added space just about takes care of the added volumes. The rate of growth of the Dewey collections now stands at 11 per cent a year. (For Statistics of the Library System as a whole, see Table I; for growth projections, Table II.)

Rotch is completely out of space, too, and this affects every aspect of its operations. The one glimmer of hope is an adjacent area of some 1,000 square feet occupied by the office of the retiring Dean, Lawrence B.

Anderson, and part of the corridor. These would accommodate one and a half years' growth if they could be incorporated into the Library. Loans at Rotch are up almost 30 per cent and the number of books for subject reserve has almost doubled. The rate of growth of the collections is now 9.6 per cent a year, reflecting the rise in the number of students in the School of Architecture and Planning.

Throughout the system we have growing difficulties with mutilation, theft, and vandalism. Particularly in the Student Center Library there is a steady toll and in the Music Library, which was equipped last year with fine quality new tape recorders and record players, the pilfering and damage is heartbreaking. It is small consolation that we see here a local reflection of a national trend.

On a more optimistic note, in April we logged the two-millionth user of the Student Center Library in 5½ years of operation. Average occupancy throughout the year is 39 at 3 a.m., 53 at noon, and 100 at 10 p.m. Total capacity is 495. Working capacity is perhaps 450, which is often exceeded at exam time.

The Archives had a busier year than ever, described by the Institute Archivist, Professor E. Neal Hartley: "The main features of our activities during the past year were increased use of record material, the taking of encouraging steps toward development of a true archival system, implementation of policies to protect individual privacy, and receipt and processing of collections of unusual importance. . . .

"This spring President Johnson gave his blessings to plans to set up an advisory committee on the Institute Archives to include members of the administration, the faculty and the Corporation. As he becomes Chairman his help can be counted on, and it is our hope that in the fall term we can create a system out of what has been largely random growth. The next step will be to publish a policy statement of guidelines binding on the several official Institute constituencies and advisory, at least, with respect to the papers of individuals."

In computer applications progress is discernible and is symbolized by a change of name of our Technical Information Program under Dr. Myer M. Kessler to Computer Applications Division. The acquisitions log and financial statements are slowly shaping up. During the year elementary and intermediate courses in computers were offered to members of the Staff in order to temper their enthusiasm with knowledge and provide a firm basis for the introduction of computer methods. We see at every turn places where life would be simplified and information made more accessible by a computer but our appetite continues to be bigger than our pocketbook and the new computer turns out to be less reliable and more expensive than the old one.

A major event in the Humanities Library this year was the gift by Mr. and Mrs. Samuel Glaser of the Class of 1925 of *The Nuremberg Chronicle* in nearly mint condition. This first printed encyclopedia takes its name from the city where it was produced in 1493. Our warmest thanks to Mr. and Mrs. Glaser.

Throughout the system the loyalty and hard work of the whole staff this year have been outstanding, and to them the Director is happy to be able to express his sincere thanks on behalf of the Institute community which we serve.

PROFESSIONAL STAFF ACTIVITIES

Karl S. Bynoe was a member of the Joint Committee on Minority Recruitment, a cooperative program: The Boston Public, Harvard, and M.I.T. Libraries, and Simmons College.

Mrs. Laura Carchia participated in the 25th annual meeting of the Committee of University Industrial Relations Librarians held at Cornell University, and was elected Chairman for 1971-72 when the group will meet in Cambridge.

Mrs. Jacqueline Colby continued as Recording Secretary of the New England Technical Services Librarians until elected Vice President/ Program Chairman for 1971-72. She has also been a supervisor and lecturer to the Cataloging Workshop of the Institute of Small Hospital Libraries.

Joseph Dagnese has continued as Chairman of the Chapter Relations Committee and Chapter Liaison Officer of the Special Libraries Association, and been appointed Deputy Chairman of the Special Libraries Association Conference to be held in Boston in June, 1972. He participated in a three-day workshop on "Library Automation," held at Endicott House in May, 1971, under the auspices of the Information Science and Automation Division of the American Library Association. He also spent the months of November and December at the Delhi University Library, India, as a Library Consultant for the Ford Foundation.

Mrs. Irma Johnson returned in September from two years as Library Consultant for the Kanpur Indo-American Program, Indian Institute of Technology, Kanpur, India.

Myer M. Kessler serves on the Cambridge Project Policy Advisory Group, on the M.I.T. Information Processing Center Advisory Board, and is a consultant to the American Council of Learned Societies for the Research and Development Project in Automated Bibliography.

Aleksander Leyfell attended a conference organized by the Northeast Universities Consortium for International Affairs at Columbia University.

William N. Locke continued as Chairman of the Committee on Linguistics in Documentation of the International Federation for Documentation, as Chairman of the Membership Committee of the American Society for Information Science and of the Committee on Constitution and Bylaws of the Association of Research Libraries. He also continued as Delegate of the New England Foreign Language Association to the National Federation of Modern Language Teachers Associations and as Liaison Officer of the American Society for Information Science to the American Council of Learned Societies.

Tovah Markowitz took a course in library automation at the University of Texas Graduate School of Library Science in August, and attended Institutes on library automation held by the American Library Association's Information Science and Automation Division.

William D. Mathews is a consultant to the American Council of Learned Societies for the Research and Development Project in Automated Bibliography.

Arthuree McLaughlin attended a *Chemical Abstracts* User Seminar on Computer-Based Services in Columbus, Ohio.

Mrs. Frances Needleman continued as Secretary of the Executive Committee, Cataloging and Classification Section, Resources and Technical Services Division, American Library Association, and was on the Executive Board of the A.L.A. Membership Committee.

Natalie N. Nicholson was a member of the Joint Committee on Minority Recruitment and continued as a member of the Urban Universities Library Committee, and of the Standards and Accreditation Committee of the American Library Association. She participated in a one week Library Management Development Institute at Miami University, Oxford, Ohio.

Margaret A. Otto was also chosen to attend the Library Management Development Institute held at Miami University, Oxford, Ohio.

Peter R. Scott was reelected Chairman of the American National Standards Institute Committee PH5-2 on Microfiche and Micro-opaques, and continues as a member of its PH5 and PH5-1 Committees. He served last year as President of the New England Chapter of the National Microfilm Association, and is chairman of the NMA Information Retrieval Committee.

STAFF CHANGES

Appointments for the year included: Margaret E. Depoplo, Assistant Rotch Librarian; Myriel C. Eykamp, Assistant Science Librarian; Geraldine A. Murphy, Assistant Science Librarian; Patricia B. Pier, Exchange and Gifts Librarian; Alicia M. Prata, Assistant Serials Librarian; Nancy J. Prolman, Cataloger; and Mary L. Utz, Circulation Librarian.

Promotions, leaves, and transfers included: Joseph M. Dagnese, Assistant Director for Technical Services, Leave of Absence; Jose B. Leone, Serials Cataloging Librarian; Arthuree R. McLaughlin, Acting Lindgren Librarian; Suanne Muehlner, Lindgren Librarian, Leave of Absence; and Margaret A. Otto, Assistant Director for Reader Services.

Resignations were received from: David Jordan, Programmer; Barbara Kohl, Assistant Rotch Librarian; Karen Kugell, Exchange and Gifts Librarian; Jose B. Leone, Serials Cataloging Librarian; Lewis Morton, Programmer; Geraldine A. Murphy, Assistant Science Librarian; Kirsti Schneider Nilsen, Circulation Librarian; Patricia B. Pier, Acting Rotch Librarian; and Claire Pulver, Assistant Humanities Librarian.

WILLIAM N. LOCKE

PROJECT INTREX

Project INTREX is a program of information transfer experiments directed toward new services and facilities for people who seek information in large libraries. The program involves research and development activities in the Electronic Systems Laboratory and operational experiments in the James Madison Barker Engineering Library.

During the past year, after five years' concentration on building up an information store and developing the essential facilities for its use, the emphasis has shifted to the study of the operations and reactions of users under varying conditions. The store consists of roughly 15,000 documents from the recent technical literature of four fields in materials science and engineering. Bibliographic descriptions of these documents are contained in the disc file of a time-shared computer; the full text of the documents is stored in a central station containing 1,500 sheets of microfiche. A number of terminals are available from which users can conduct bibliographic searches and gain access to the full text of relevant documents.

In controlled experiments with M.I.T. subjects comparisons were made between the retrieval effectiveness of INTREX procedures and conventional library techniques, and the effectiveness of different parts of the bibliographic description and full text in guiding the user to relevant documents was tested.

A start has been made on a cost analysis for an operational information system with INTREX features. When the research activities of Project INTREX are concluded, probably in mid-1972, the results should enable system designers to write cost estimates as well as technical specifications.

The operation of INTREX facilities in the Barker Engineering Library

Table I Statistics

	Volumes Added			Volumes in Library			Volumes Loaned		
	1968/69	1969/70	1970/71	1968/69	1969/70	1970/71	1968/69	1969/70	1970/71
Archives	2,235	1,511	2,181	50,730	52,213	54,396	—	—	—
Dewey	25,691	27,343	32,925	272,446	299,913	332,803	81,491	83,992	89,138
Engineering	9,911	13,177	18,261	135,104	147,534	164,784	47,297	57,966	71,849
Aero and Astro	5,786	6,542	4,729	74,767	81,222	85,657	10,797	12,898	14,556
Materials	396	179	130	1,083	1,235	1,287	1,725	1,008	959
Space	1,449	359	387	7,752	8,111	8,498	1,932	2,033	1,880
Humanities	10,436	12,145	10,066	169,972	180,621	188,810	37,429	40,577	43,495
Music	1,255	1,230	1,299	14,153	15,383	16,680	5,115	6,648	15,244***
Rare Book Room	—	8	8	20,259	20,267	20,273	—	—	—
Reserve Book Room	—	—	—	—	—	—	12,014	10,164	5,154
Rotch	5,049	5,711	7,269	68,058	73,438	80,538	23,749	28,711	54,653***
Science	8,227	10,585	9,882	254,943	264,439	273,655	56,644	66,138	61,960
Chemistry	—	2,034	187	—	2,037	2,225	—	—	—
Lindgren	1,969	2,086	1,883	20,616	22,679	24,566	5,315	5,827	6,280
Physics	—	4,634	2,382	—	4,690	7,083	—	—	—
Student Center	3,626	5,130	5,292	20,095	25,225	30,517	—	—	—
Technical Services	—	43	103	2,917	2,933	3,036	—	—	—
NEDL	—	—	—	20,656	19,262	19,262	—	—	—
TOTAL	76,030	92,717	96,984*	1,133,551	1,221,202	1,314,070	283,508	315,962	365,168**

*Not including 35,000 microfiche, 8000 slides, 3400 maps, 1600 photographs, and 1000 "other"
**Not including 20,000 volumes to Microreproduction Laboratory for copying
***Includes non-book materials omitted in previous years

Table II Capacity and Projected Growth (in Volumes)

	Capacity (with possible additional shelving)		Number of Volumes				
				Projected			
Library	Working	Absolute	As of June 30, 1971	1972	1973	1974	1975
Dewey (Management, Economics, Political Science)	229,000 (269,000)	344,000 (404,000)	333,000	366,000	403,000	439,000	479,000
Hayden Building (Science and Humanities inc. Music, excl. Archives)	394,000 (407,000)	591,000 (611,000)	502,000	527,000	553,000	581,000	610,000
Lindgren (Geology, Meteorology Oceanography)	20,000 (22,000)	30,000 (33,000)	25,000	27,000	29,000	31,000	33,000
Rotch (Architecture and Urban Studies)	52,000 (54,000)	78,000 (81,000)	81,000	90,000	97,000	105,000	114,000

is an early example of the mixture of advanced technology and conventional practice that will characterize research libraries in the next decade. In the constantly changing regime of such a library, the user will be particularly dependent on effective aids.

CARL F. J. OVERHAGE

NORTHEAST RADIO OBSERVATORY CORPORATION (NEROC)

During the past year the Northeast Radio Observatory Corporation, a consortium of 13 educational and research institutions to which M.I.T. belongs, completed its design studies for a very large telescope for radio and radar astronomy and assumed full operational responsibility for the 120-foot Haystack Telescope at Westford, Massachusetts.

The design for the new telescope, the result of five years of planning and engineering studies supervised by the Lincoln Laboratory, is based upon a 440-foot diameter fully steerable paraboloid antenna enclosed in a radome and operable throughout the wavelength range of 1.2 centimeters to 10 meters. The telescope's large and accurate reflector surface, its precise pointing capability and its flexibility to accommodate research instrumentation is intended to provide major new capability for solar system research, continuum analyses of galactic and extra-galactic sources, spectral line studies, and high resolution studies via interferometry, some involving new, very long baseline techniques. Along with the completed design study, a proposal has been submitted to the National Science Foundation requesting authorization to build a new national observatory at a cost of up to $40 million.

The Haystack antenna has been transferred by the Air Force from the Lincoln Laboratory to M.I.T. for operation as a university facility under the auspices of NEROC. The antenna and associated equipment comprise a powerful and versatile instrument capable of effective operation over a wavelength range from 21 cm. down to 8 mm. During a typical week the antenna is used for about 100 hours of scientific observations by about 30 students and faculty from almost a dozen research institutions. Funds for operating costs are provided to NEROC by the NSF (for radio astronomy) and NASA (for radar studies of the planets).

PAUL B. SEEBRING

OPERATIONS RESEARCH CENTER

The Operations Research Center brings together faculty and students from various M.I.T. departments to conduct an academic program and to conduct research on the science and technology of decision making.

The interdepartmental Ph.D. program has continued to offer an Institute-wide focal point for doctoral education in operations research. During the past year, students in the program have come from at least a half-dozen departments. Also, as the capacity of the Center has increased, it has been possible to take on more students coming to M.I.T. specifically to study in this field. A further educational development has been the awarding, for the first time, of specified Master's degrees in operations research, as approved last year by the Committee on Graduate School Policy.

During the past year, the major research activities of the Center's faculty and students have been in the areas of basic mathematical methods, transportation science, and operations research applications to public systems.

In the mathematical methods area, work has been progressing on studies in optimization theory, multi-attribute utility functions and their use in decision analysis, multivariate Bayesian inference, extreme order statistics arising in mixing processes, the relation of optimal control theory to industrial management processes, and in probabilistic models.

In transportation science, good progress is being made on studies of the operational problems of automated transportation systems consisting of small vehicles travelling in discrete time slots; air transportation systems with particular reference to terminal area traffic control; and techniques for analysis of ship operations and cargo facilities.

A substantial portion of the Center's effort has gone into opening up new research areas in public systems. Work is in progress on the allocation of urban emergency units such as police patrol cars, ambulances and fire apparatus; systems analysis of the delivery of health care; library operations; water resource development; and citizen feedback systems which can increase the quality and quantity of citizen input to government.

Support for the Center's research is varied. A National Science Foundation grant supports innovative work in public systems. The citizen feedback work is also sponsored by NSF and by other sources as well, including the Ford Foundation Urban Grant to M.I.T. and the Massachusetts Department of Education. A grant from General Motors supports fundamental work in transportation science. The Mobil Oil Corporation supports basic work in model-building systems. The Army Research Office-Durham continues to support fundamental investigations into operations research methodology.

JOHN D. C. LITTLE

PROJECT MAC

Project MAC is an interdepartmental laboratory for computer research and development. The laboratory includes 12 separable but interacting Groups staffed by approximately 265 faculty members, staff members, and students.

During the past year, Professor J. C. R. Licklider resigned from the directorship of Project MAC to concentrate on research with several of the Groups and Professor Edward Fredkin was appointed Director. The Artificial Intelligence Laboratory which for several years had operated as a research Group within Project MAC, became an independent interdepartmental laboratory.

As in previous years, Project MAC was supported primarily by funding from the Information Processing Techniques Directorate of the Advanced Research Projects Agency (ARPA). Several projects under the Project MAC umbrella were funded by other agencies: work in extensible languages by the National Aeronautics and Space Administration (NASA); work in interactive problem solving and decision making by the Office of Naval Research (ONR); research on "programming generality" by the National Science Foundation (NSF); and development of a computer system for "dynamic modeling" by the Behavioral Sciences Directorate of ARPA.

For the second year, Project MAC has deliberately fostered participation in research by undergraduate students. The number of undergraduates at Project MAC has increased from about 40 two years ago to 80 now. During the same period, the number of graduate student members has risen from about 30 to 40. If the members of the A.I. Laboratory were to be included for purposes of comparison with last year, the overall growth of Project MAC would be from about 270 to about 330, an increase of 22 per cent. Most of the academic members of Project MAC are members of the Departments of Electrical Engineering and Mathematics or the Sloan School of Management.

Highlights of the work of the 12 principal Groups are presented below. The descriptions are necessarily brief; details can be found in the Annual Report of Project MAC for 1970 - 71.

AUTOMATA THEORY

Abstract complexity theory, which, under Professor F. Hennie, has been a central topic of research in the Automata Theory Group in recent years, has become a reasonably developed chapter in the theory of computability. The basic phenomena associated with the classification of computations according to their time and space requirements are now

rather well understood, and further refinements in the abstract theory are likely to be of diminishing importance to the computer scientist. Current interest within the group is concentrated on combinatorial and statistical analyses of a variety of algorithms commonly arising in computation. The goals of work in this area are to develop methods for designing good algorithms for problems of practical interest and to devise techniques for verifying the optimality of algorithms.

COMPUTATION STRUCTURES

The principal results for the past year of the Computation Structures Group, led by Professor Jack Dennis, were in the theory of asynchronous systems, in the study of parallelism in computations, and in formulating in specific terms the concept of a common base language.

Petri nets are a formal scheme for the representation of concurrency in processes and asynchronous systems. In their task Petri nets stand out in relation to other schemes because of the clarity with which they are able to express parallel actions, resolutions of conflicts, and interaction among processes. To develop an understanding of the nature of Petri nets and the nature of asynchronous processes, the Group has been studying some subclasses of Petri nets and several new subclasses of interest and useful results about them have been found.

Another effort of the Group has been to do away with the tedious and unnecessary debugging that is required to make newly designed hardware function according to specification. Progress has been made on several fronts; for example, the commonly accepted complete set of logic gates does not constitute a complete set for the design of asynchronous circuits, and progress is being made toward answering the fundamental question of what *is* a complete set of gates.

The Group is also working toward the definition of a common base language that can serve as a target representation for procedures translated from a variety of practical source languages, for example, FORTRAN, and ALGOL. An interpreter for the base language and a precise description of the translation of source programs into base language programs, would constitute a complete schema for the formal definition of the semantics of programming languages in terms of a common set of semantic notions. The base language can serve as the functional specification for a computer system. This idea has led to the development of new concepts of computer system organization that are being studied and evaluated.

COMPUTERS AND PEOPLE

When computers are used in any facet of the operation of society, the specific technical characteristics and capabilities of the computer system

employed constrain and significantly influence the behavior of the large system consisting of hardware, software and people. It is known that computer hardware should be designed and evaluated in the context of the software that provides the interface with the users. We now must learn how to design and evaluate computer systems in the context of the community of people affected by their use. Two related problem areas are being studied: the interaction between characteristics of computer systems and the individual and collective behavior of the people affected by their use; and the design of computer systems conducive to modes of operation that are at least not objectionable from a human standpoint.

Work in the first area has been in progress for about three years, although at a low level of intensity. Work in the second area has developed a model of the protection structures and access control mechanisms of a multi-access computer system capable of preventing unauthorized release of information. The model includes spheres of protection constructed out of abilities to reference programs and data segments. It can be shown that, under appropriate conditions, calling spheres cannot spy on their callees, nor the callees on their callers. The model also includes facilities for keeping records of critical action (by system programmers, for instance) and for allocating responsibility for whatever a process does.

COMPUTER NETWORKS

Research and experimental development in the relatively new field of computer networks passed several milestones during the past year, under the joint leadership of Professors F. J. Corbató and J. C. R. Licklider. At the end of the year, both the MULTICS/GE-645 computer system, which is the research vehicle of the Computer System Research Group, and the Dynamic Modeling Computer Graphics PDP-10 computer system were operating almost regularly as "host computers" in the nationwide experimental network of time-shared computers sponsored by the Advanced Research Projects Agency.

The intercommunication part of the network has several small computers, called Interface Message Processors (IMPS), one at each site. The IMPS, designed and implemented by Bolt Beranek and Newman, Inc., with Honeywell Model 516 computers, are interconnected by leased lines capable of transmitting 50,000 bits per second. An IMP was installed at Project MAC in April, 1970. The IMP was then interfaced electronically to the host computers, the GE-645 and the PDP-10. Next GE-645 and PDP-10 programs were prepared to control communication between the hosts and the IMP. Then programs were prepared to control

communication between one host's control program and another's. And so on, until the "users programs" running in the host computers, and through them the human users at their consoles, could interact with one another across the country.

By the summer of 1971 attention was shifting from merely demonstrating capabilities of remote interaction to developing those capabilities to the point of full effectiveness, economy, and convenience. It is evident that there is much work to be done to realize the rather clearly envisioned part of the potential of computer networks. Beyond that part there appears to be a very large but unstructured potential that must be understood through research. One thinks of interoffice networks that will make paper mail and manual filing obsolete, interlibrary networks that will change the pace and meaning of "interlibrary loan," access to centralized data banks and interconnections among geographically distributed data bases, and so on. The issues that concern the interactions of technology and our informational environment appear to be as complex and demanding as those that concern the interactions of technology and our physical environment.

COMPUTER SYSTEMS RESEARCH

The period from July, 1970 through June, 1971 can best be characterized as a year of change for the Computer Systems Research Group under the leadership of Professor Corbató. Changes of status and of emphasis predominated.

The most significant change of status had to do with the MULTICS system, which was again a primary focus of the Group's activity. Administered by the M.I.T. Information Processing Center, MULTICS was available to the M.I.T. user community for the entire reporting period; for the first time, then, this report covers a system which is no longer used only experimentally. Indeed, in view of the system's increasing acceptance by its public, the status of MULTICS may be said to have changed from laboratory research to operational success.

With this transition of MULTICS into operational status, the Group accelerated its planned effort to disseminate widely the technical knowledge and social and philosophical ideas that underlay the design of the system. "Exportation" of MULTICS has several aspects, ranging from physical exportation of hardware and software to exportation of the design and operating principles through journal articles, symposia, and the publication of manuals. During the year, MULTICS systems were inaugurated at the Rome Air Development Center and the Honeywell Information Systems Inc.'s software facility at Waltham, Massachusetts. The size of the MULTICS user population continued to grow almost lin-

early throughout the year. At year end, over 700 users were registered individually, and approximately another 700 users were using MULTICS under group registrations.

A second major change in the emphasis of the Computer System Research Group has to do with the ARPA network. Several members of the Computer System Research Group are members also of the Computer Networks Group and are working full-time on network research. MULTICS is expected to be an active site on the Network. Many features have been added to MULTICS to enhance its utility from the viewpoint of network users, and more improvements are planned.

DYNAMIC MODELING AND COMPUTER GRAPHICS

Under the leadership of Professor Licklider, the Dynamic Modeling and Computer Graphics Groups progressed in their experimental development of a computer system to facilitate the modeling and testing of complex ideas. The aim is in part to devise and improve computer tools and techniques which can help people sharpen and clarify their thinking, and in part to amass a significant repertory of such tools and techniques and organize them into a coherent system. After two years of technique research and software development, the joint effort of the two groups is now at the stage in which parts are fitting together. For example, using a complex of program modules that handle stylus input, character recognition, parsing of two-dimensional strings, compilation of algebraic and trigonometric expressions, and display of surfaces in three dimensions, one can hand-print on a computer-input tablet a complex equation and in a few seconds examine the corresponding graph, rotate it to see it from various points of view and zoom in on it to examine selected details. With other software components, one can set up a hypothetical model of a neural network and systematically explore the effects of several variables on the pattern of response to controlled stimulation.

The computer system is designed to make it easy to select from a large repertory of procedures and techniques, the ones most appropriate for the representation of a particular process or organization and then to construct a model, explore it, test it, modify it, retest it, and so on. Major emphasis is being placed on making the system rapidly responsive and on adapting its information-processing power to the needs of human problem solving and decision making.

MATHLAB

Under the supervision of Professors William Martin and Joel Moses, the project known as MATHLAB has continued to develop the MACSYMA System for interactive algebraic manipulation. MACSYMA is now both a useful

tool for the solution of real problems and a convenient base for research in algorithm analysis and development of advanced systems for applied symbolic mathematics.

During the past year, using MACSYMA, the properties of the dispersion relation of a linear system were investigated, statistical mechanics problems were explored, and quantum mechanical calculations were performed.

Future work will include investigation of both algebraic manipulation algorithms and general methods of obtaining simplification rules for functions defined by differential equations. While expert humans are still more "intuitive" than MACSYMA in the decision of approaching a problem, an appropriately programmed computer can more rapidly and accurately handle large algebraic manipulations than can even the most expert of humans. In the past year MACSYMA has shown itself to be an invaluable helper to those engaged in serious mathematical work.

MODELING AND SIMULATION

A crude version of the new simulation language SIMPL, created by the Modeling and Simulation Group under the leadership of Professor Malcolm Jones, was initially operable by the beginning of August, 1970. After considerable testing and modification, it was decided to undertake the design and implementation of a new system which would be more efficient in all respects than the old one, and which would easily accommodate all of the additional features of the full SIMPL system.

The new system was designed and programmed, beginning in February, 1971, and is now in the final stages of testing and debugging. Besides being more efficient in translation, compilation, and execution, Version 2 includes a complete tracing capability, allows external activities, produces numerous simulation-oriented statistics, and supports the interactive SIMPL Monitor. The SIMPL Monitor itself is written and working. The Monitor is a very flexible run-time system which allows the user almost complete freedom to inspect and modify his model, and then continue or restart the simulation. The SIMPL system has been thoroughly documented.

ORGANIZATIONAL INFORMATION SYSTEMS

The Organizational Information Systems Group, under the leadership of Professors Malcolm Jones and J. I. Elkind, has been working to develop and to understand how to use interactive information systems in the administration and operation of organizations. The class of systems investigated incorporates a data base that describes the present and past state of the organization, models that can be used to predict future states,

and procedures that assist in making planning and control decisions. Also central to these systems are facilities that allow users to interact with this body of data, models and procedures. Much of the work is being done in the context of specific applications. Since June, 1970, research deriving from the MACAIMS Project begun in 1968 has focused on the development of general purpose data manipulation facilities on MULTICS and on the application of these facilities in management systems for Project MAC. The principal projects undertaken during the last year were: Design and implementation of a set-theoretic data manipulation system on MULTICS; development of management information systems for Project MAC and for the Sloan School; studies of access control and privacy in computer data-base systems; studies of models and modeling of organizations.

PROGRAMMING LINGUISTICS — EXTENSIBLE LANGUAGES

The main theme of the research of the Programming Linguistics (Extensible Languages) Group, under the leadership of Professors R. M. Graham and Arthur Evans involves improving understanding of the basic concepts in programming languages. Work has centered upon language formalization and language extension.

Two activities have occupied the Group's attention on a long-term basis: teaching the undergraduate subject Programming Linguistics, 6.231, and supporting the languages PAL and BCPL. In 6.231, the basic concepts in programming languages are taught largely by exhibiting a formalization of the semantics of PAL, a language designed as a teaching and learning tool. The creation and polishing of the formal definition of PAL have provided insight into the problems, and valuable suggestions for ways to proceed. PAL is implemented on several computers, the MULTICS implementation being used currently by M.I.T. students. Eighty to 100 students per term use PAL on MULTICS.

BCPL has been an interest of the Group since it was devised by Martin Richards when he was at Project MAC in 1967 and 1968. The language was designed to facilitate the writing of compilers. As a separate activity, the Group has been active in making BCPL available outside of M.I.T. The most exportable version of the language is that on the IBM-360, and the Group has provided tapes of the compiler for 16 installations.

PROGRAMMING LINGUISTICS — FORMAL SYSTEMS

The focus of the research and teaching activities of the Programming Linguistics (Formal Systems) Group, under the leadership of Professor John Donovan, is programming languages. The theoretical work is aimed at developing quantitative measures for (a) computation specified by a

program written in a typical programming language; (b) translation of programs; (c) recognization of programs.

The Group's research on complexity measures for programming languages is concerned with a theory of complexity of algorithms implemented in typical programming languages. The complexity of a program may be interpreted in many ways, each is measured as some function of the amount of a particular resource used by the program in processing an input value.

The research on complexity measures for the process of translation of computer languages also employs quantitative measures. Here the framework is provided by Canonic Systems, a mathematical-logical construct developed by the Group. The Group has proved a number of theorems that relate classes of Canonic Systems to existing formal grammars.

In conjunction with Honeywell Corporation, the Group is presently developing a language implementation system to be used to provide tools for language designers and compiler writers. It will provide an automatic lexical analyzer, syntax analysis method, and a general method of semantic interpretation, using both Canonic Systems and PL/1.

EDWARD FREDKIN

RESEARCH LABORATORY OF ELECTRONICS

Established at the end of World War II as the Institute's first interdepartmental laboratory, the Research Laboratory of Electronics has established a research environment for faculty members and students. Initially organized to encourage interactions between teaching and research in the Departments of Electrical Engineering and Physics, the Laboratory has had projects involving participants from as many as a dozen departments. The research groups, currently numbering about 30, conduct research in three broad areas: communication sciences, general physics, and plasma dynamics.

All of the research in R.L.E. involves academic faculty members and students. Approximately 100 members of the faculty are affiliated with the Laboratory, working with about 300 graduate students and nearly 100 undergraduates. The research in R.L.E. spreads over a broad spectrum of topics and thus provides opportunities for a wide variety of student thesis work. During the past year, the research provided the basis for 32 doctoral, 4 Engineer, 38 Master's, and 65 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 the Atomic Energy Commission, the National Science Foundation, the National In-

stitutes of Health, and the National Aeronautics and Space Administration.

GENERAL PHYSICS

The research in general physics is largely based on atomic phenomena. The experimental techniques required to observe basic properties of matter and to exploit them in engineering applications span most of the electromagnetic spectrum from radio wavelengths to x-rays. Other experimental requirements include the use of extremely high frequency vibrational waves, the use of liquid helium temperatures, and extensive use of computers. A few of the research topics in this area are as follows:

In the molecular beams group, Professor John G. King and his associates have completed a number of low temperature atomic beam experiments but are working increasingly on various molecular microscopy problems. There are many applications for these techniques, such as the study of gas and vapor transport through living membranes (with collaborators at Harvard and Tufts Universities). Also, the desorption of neutral atoms and molecules that are bound on surfaces by means of a scanned beam of ions or electrons can provide a resolution of 5 angstroms. These methods of microscopy differ from others in that the particles observed interact through the weak chemical forces at surfaces, and are thus directly relevant to biological and chemical problems.

Under the direction of Professors Malcolm W. P. Strandberg and Robert L. Kyhl, the microwave spectroscopy group has demonstrated the usefulness of studying non-linear effects in electron magnetic resonance spectroscopy for determining in a convenient fashion properties of these systems, such as line shape and spin decoupling with strong RF fields.

Professor Daniel Kleppner and his associates in the atomic resonance and scattering group have succeeded in creating a beam of molecules composed of atoms which have no chemical affinity. The diatomic molecules are bound solely by the feeble Van der Waals force which exists between all atoms. The first molecule created, CsHg (cesium-mercury), represents one of a large class of paramagnetic Van der Waals molecules which are candidates for study by magnetic resonance methods. A second area of progress is in the precision comparison of the magnetic moment of the electron in hydrogen and deuterium. The results have resolved a conflict between theory and previous experiments in other laboratories.

The radio astronomy group, under the direction of Professors Alan H. Barrett and Bernard F. Burke, has concentrated its efforts primarily in the areas of spectral line observations, very-long-baseline interferometry (VLBI), pulsar observations, and microwave studies of the terrestrial

atmosphere. Professor Barrett and his colleagues have studied the composition of the interstellar medium via OH, H_2O, CH_2O, and CH_3OH molecules from interstellar clouds and infrared sources.

Professor Burke and his associates have studied several of the brightest H_2O maser sources by very-long-baseline interferometry, and maps were made of the emission associated with the Orion nebula and the very distant and intense source W49.

Professors Burke and David H. Staelin have studied the propagation characteristics of the interstellar medium near 100-600 MHz while observing pulsar radio emission. The pulsars emit radio energy in a regular series of pulses over a wide frequency interval and, hence, are valuable probes of the interstellar medium.

The program of atmospheric measurements is largely under the direction of Professor Staelin and has included observations of mesomorphic and stratospheric ozone at 101 GHz, molecular oxygen at 53 GHz, and stratospheric water vapor at 22 GHz. As part of a program to use microwave sensors to provide atmospheric temperature profiles from earth orbit, aircraft tests have shown that the method is feasible even over heavy clouds.

During the past year, research on millimeter wave solid-state devices and circuits and on device characterizations was continued under direction of Professor Donald H. Steinbrecher. Sixty-gighertz receiver front end mixer-preamplifiers with noise figures of 6 dB$\pm$ 0.5 dB were demonstrated by John Rudski. Avalanche-diode small-signal, nearly-linear characteristics were determined theoretically by a new first-order nonlinear model developed by Dean F. Peterson.

The major accomplishment of Professor Robert E. Stickney and his colleagues in the physical electrons and surface physics group was the first successful observation of the diffraction of helium atoms from a clean metal surface. Since all previous attempts in other laboratories had been unsuccessful, several different theoretical arguments have been postulated as possible explanations of the reason helium diffracts from alkali halide and tungsten carbide surfaces but not from clean metal surfaces. The group also continued to study the kinetics and thermodynamics of absorption and desorption processes, evaporation processes, catalytic reactions, and gas-solid (e.g., oxidation) reactions. These studies benefited from the development of an Auger electron spectrometer that enables one to determine the chemical composition of a solid surface over a wider range of temperature (e.g., up to 2500°K for tungsten) than previously possible.

The work of the gas laser group of Professors Hermann A. Haus and Paul W. Hoff is concerned with the production of short, high intensity

laser pulses utilizing gas cells of relatively simple construction with low gas-flow rates. Q-switching and cavity dumping and amplification by means of a CO_2 laser utilizing a conventional low pressure discharge have yielded pulses of 20 ns duration and 20 kilowatts peak power. These are the shortest pulses of this intensity achieved with a low pressure system.

A laser applications group was formed in January under direction of Professor Shaoul Ezekiel. The group's areas of interest include: (a) long term laser frequency stabilization using resonance absorption in a molecular beam as a sharp and stable reference; (b) measurement of three-dimensional flow using laser doppler techniques; (c) application of pulsed and cw holographic techniques for measurement of dynamic behavior of materials and structures.

PLASMA DYNAMICS

A major goal of the plasma dynamics program is extension of the basic understanding of phenomena in ionized gases and in solids in ways that are relevant to such problems as controlled fusion, space physics and collective phenomena in solids. The research includes methods of producing highly ionized plasmas by electron beam injection, high powered lasers, microwaves, low pressure arcs and so forth. Plasma diagnostic techniques involve measurements in various portions of the electromagnetic spectrum (microwave, millimeter wave, infrared, optical).

Professors William P. Allis, George Bekefi, Sanborn C. Brown, Bruno Coppi and E. Victor George, and Drs. Ryszard Gajewski and Peter A. Politzer of the plasma physics group have been engaged in four major areas of study:

1. Experimental and theoretical work concerning the physics of high temperature plasmas carrying high currents typically of the order $10^3 A/cm^2$. The ALCATOR toroidal device being built in collaboration with the Francis Bitter National Magnet Laboratory is nearing completion. In addition to Ohmic heating, injection of microwaves is being contemplated with the view of enhancing the plasma temperature and its DC resistivity.
2. A linear quadrupole (SLIM) has been completed and experiments have begun. In this device we shall study the basic physics of plasma confinement and instabilities in a two-dimensional quadrupole magnetic field.
3. Through the courtesy of EG&G we have obtained a long-term loan of the relativistic beam machine which produces a 100KA beam of electrons with an energy of 300 KV. We are presently assembling this device

and hope to begin experiments this summer. The major aim of this work is to inject the beam into a high density plasma and initiate turbulent heating of the medium. Such type of turbulent heating appears to have considerable promise in raising the temperature of plasmas to a range of interest to fusion.

4. The production and heading of plasma by means of high intensity lasers is being carried out. Special attention is paid to molecular lasers, in particular the high pressure transversely excited atmospheric pressure (TEA) laser in CO_2. In conjunction with this work a strong diagnostics effort using novel spectroscopic techniques is being pursued.

The research of the active plasma group (Professors Abraham Bers, Richard J. Briggs, Ronald R. Parker, Keith I. Thomassen and Louis D. Smullin) is centered around the study of plasma dynamics in the regime of interest for controlled thermonuclear fusion research. A major effort at present is the development of plasma heating methods for the Alcator experiment and several small-scale experiments are underway to further our understanding of RF heating near the lower hybrid frequency. Other areas of concern include plasma diagnostic methods, feedback stabilization of plasma instabilities, basic understanding of anomalous heating by induced plasma currents, and theoretical studies of direct conversion of plasma energy to electricity.

In the area of plasma effects in solids, Professor Bers and his students have focused their attention on the interaction of acoustic and electron surface waves in adjacent piezoelectric semiconductor structures. The resonant enhancement of the interaction in a magnetic field was confirmed experimentally.

COMMUNICATION SCIENCES AND ENGINEERING

This research spans a broad range of topics pertinent to communication processes in man-made and living systems, as well as interactions between them. Fundamental studies of signals and systems are coupled with various applications such as speech and picture transmission, seismic detection and optical communication channels. A major portion of the effort is related to the life sciences. A combined program of research and training in communications bioengineering includes areas such as communications biophysics, neurophysiology, cognitive information processing, and speech communication. Much of this work concerns the sensory or perceptual mechanisms and the related program in linguistics seeks to improve our understanding of languages, which form the basis for communication.

The processing and transmission of information group has been concerned with efficient and reliable communication techniques. Professor

Robert C. Gallager has been working on branching random walks and their applications to sequential decoding. Professor Peter Elias and his students have been completing work on quantization, studying problems in digital data transmission, and using information theory techniques to answer basic questions in information storage retrieval and in the design of switching and sorting networks.

Professor Robert S. Kennedy and Estil V. Hoversten and their students have been studying the fundamental limitations on optical communication through the clear turbulent atmosphere, through clouds, and through over-the horizon scattering channels. Scatter propagation experiments are being performed over an 18 KM path in conjunction with Lincoln Laboratory.

The detection and estimation theory group, under direction of Professors Harry L. Van Trees and Arthur B. Baggeroer, has continued work on the application of optimal detection and estimation procedures to specific physical problems. In cooperation with the Woods Hole Oceanographic Institution, Professor Baggeroer has begun the development of a system to provide high-resolution maps of the ocean bottom.

The research of the speech communication group, under the direction of Professor Kenneth N. Stevens, William L. Henke and Alan V. Oppenheim, and Dr. Dennis Klatt, has continued to investigate the acoustic manifestations of speech, the physiological processes that are involved in speech production, the perception of speech, and the acquisition of speech sounds by children.

The past year has been a productive one for the linguistics group under the direction of Professors Morris Halle and Noam A. Chomsky. Work has been carried on in various areas of interest to the group, including questions of syntax of complementation in English, the basis of syntax, fundamental issues in syntactic theories, and the accentology of the Slavic languages.

The cognitive information processing group, under the direction of Professor Murray Eden, is studying the ways in which humans process visual and auditory information, as well as computational techniques to simulate these cognitive activities. Included are procedures for discovering perceptual errors in the reading of medical x-rays, and a method for obtaining the internal structure of arbitrary objects through computer processing of multiple x-ray images. Professor Ian T. Young has supervised the construction of a microscope with attached vidicon scanner so that large populations of blood cells may be studied in order to classify anatomical features and to study cell properties such as contact adhesiveness. Professor William F. Schreiber has been working on a digital fac-

simile transmission system for newspaper use, with possible eventual application to x-ray transmission.

Several projects designed to develop aids for the handicapped have been completed this year. Professor Francis F. Lee has successfully applied tactile feedback of pitch information to allow deaf subjects to control their voices in an acceptable way, while Professor Donald E. Troxel has continued to develop techniques for TV scan acquisition of characters from printed text, as well as a model for the computer generation of handprinted characters. Professor Jonathan Allen has continued development of a complete system for the conversion of unrestricted text to speech. A dictionary of basic words based on a random sample of 1,000,000 words of running text has been compiled, together with a systematic algorithm for letter-to-sound correspondences.

The communications biophysics group, under the direction of Professor William M. Siebert, continued its efforts to obtain a better understanding of auditory processes through an application of physiological and psychological experiments of the devices and methods of modern technology.

Work in auditory psychophysics, supervised by Nathaniel I. Durlach and Professors Louis D. Briada, H. Steven Colburn, and Julius L. Goldstein, has included continued study of combination tones, periodicity pitch, intensity resolution, and short-term auditory memory, and continued development of the computer-controlled laboratory facilities.

Work on auditory physiology (in collaboration with the Eaton-Peabody Laboratory of the Massachusetts Eye and Ear Infirmary) continued with studies of (1) transmission of mechanical and electric signals in the ear by Professors Thomas F. Weiss and William T. Peake and their associates (2) coding of acoustic stimuli into neural responses in the auditory nerve and cochlear nucleus by Dr. Nelson Y-S. Kiang, Prof. Goldstein and Professor Weiss and (3) transformation of nerve signals in brain stem nuclei by Professor John J. Guinan, Jr.

The objective of the group's biomedical engineering research, under the direction of Professors Stephen K. Burns and Roger G. Mark, is to apply engineering technology to practical problems in patient care, health delivery systems, and clinical research. Our activities are not restricted to particular organ systems, although we have a strong interest in the cardiovascular system. Our research interest goes beyond the level of bioinstrumentation development into the clinical applications and medical research problems themselves. A well-equipped bioengineering laboratory has been established as a joint Harvard-M.I.T. endeavor at the Thorndike Memorial Laboratory of Boston City Hospital. This

facility serves as a base of operations for engineering activities within the hospital community.

Professor Jerome Y. Lettvin and his associates in the neurophysiology group have followed several related paths during the past year. They have investigated the teledendron as a shaped filter in the time domain (a transformer from temporal to temporo-spatial codes). Computer models of the proposed filters have shown the behavior expected. In addition the study of nerve membranes has yielded a semiconductor model. Several new instruments have been devised — among them an operational amplifier, a semiconductor model for membrane behavior, and a heart sound analyzer.

HENRY J. ZIMMERMANN

OFFICE OF R.O.T.C. PROGRAMS

The past year has been highlighted by the implementation of changes in curriculum recommended by the R.O.T.C. Study Committee in the spring of 1970. The changes have proceeded smoothly.

Enrollment in M.I.T.'s Army R.O.T.C. Program at the beginning of the 1970-71 school year stood at 80, up 3 from the previous year. Of that new enrollment total, 26 were new freshmen and 11 entered the program from Basic Summer Camp into the third year through the two-year program. Twenty of these cadets were provided scholarships with a total annual value of approximately $76,000. Sixteen of the scholarships were for four years, two for three years, and two for two years.

Seventeen graduating seniors were commissioned this year. Efforts to match individual interests and desires with branch assignments within the Army proved to be more successful than at any time since the adoption of the General Military Science Program at M.I.T. Eleven graduates have been designated Distinguished Military Students. Four applied for and were offered Regular Army commissions. One senior cadet was placed by the Department of the Army among the top 5 per cent of graduates nationwide and will now attend graduate school at Yale University at government expense. A second graduate was selected for medical training and will attend Duke University Medical School at government expense.

PERSONNEL

Majors Stanley H. Hyman, Joseph G. McCoy, Jr., and Wayne G. Bauer, Sergeant Major Donald J. Bellevue, and Master Sergeant William E.

Anderson were reassigned in the spring of 1971. Major Francis W. Creighton, Captain Kevin M. Upton, Sergeant Major Joseph N. Courtois, and Master Sergeant Jessis R. Nobles have thus far been accepted to fill the resulting vacancies.

FREDERICK MCGARRY

SEA GRANT PROGRAM

The National Sea Grant Program originally established under the National Science Foundation to support education, research, and advisory services in the development of marine resources, was authorized by Congress in 1966. This vital national program is now an important element and the link with educational institutions for the Commerce Department's National Oceanic and Atmospheric Administration. The program continues to expand greatly and now supports Institutional Programs at 14 universities, Coherent Area Projects at nine others including M.I.T., and over 45 other individual projects.

In 1967, M.I.T. received GH-1, for Ocean Engineering Curriculum Development, the first project grant awarded by the National Sea Grant Program. This project produced the original five M.I.T. ocean engineering textbooks, which have been widely accepted, both in this country and abroad, as major contributions in the ocean engineering field. This series has been expanded to eight by the addition of three new books in 1971.

Effective June 1, 1970, M.I.T. received Sea Grant GH-88, for $217,900 from the National Sea Grant Office in support of the first year's effort under a Coherent Area Project entitled, "Ocean Utilization and Coastal Zone Development." M.I.T. matching funds of $123,164 combined with the Sea Grant support to provide a total program effort of $341,064 during 1970-71. The first installment ($100,000) of a three-year grant by the Henry L. and Grace Doherty Charitable Foundation, Inc. provided the majority of the required matching funds.

In July 1970 the Institute's Sea Grant Project Office was established with Professor Alfred A. H. Keil as Program Director. Mr. Dean A. Horn joined the Program as Executive Officer in September, 1970. The objective of the Sea Grant Program is to concentrate its resources and bring its experience to bear on efforts leading to greater ocean utilization and better coastal zone development with due regard for resultant ecological changes. Emphasis will be on those problems which are crucial on a national scale while, at the same time, paying close attention to problems of the New England coastal regions.

Inherent in these efforts is the search for increased application of

existing and newly emerging technology, along with understanding the impact of foreseeable marine-related developments on the social, economic and political fields, both nationally and internationally, as well as the restraints these fields may have on further developments.

ALFRED A. H. KEIL

SPECTROSCOPY LABORATORY

The work of the Spectroscopy Laboratory continues to benefit from the power of the laser and the virtues of large diffraction gratings of high quality. In brief summary, Professor George R. Harrison has now ruled numerous gratings on his Mark-C engine which are in use by astronomers, physicists and chemists throughout the world. Recent gratings have had a quarter of a million grooves 12 inches long ruled over an area 16 inches wide.

Work has continued on the application of lasers to problems of high-resolution spectroscopy and of energy transfer between gaseous molecules.

One group within the center has determined the Raman spectra of a number of new proteins, including insulin, beta-lactoglobulin and bovine serum albumin. The latter is the largest protein whose Raman spectrum has yet been successfully determined. The same group has continued its studies of molecular conformations by means of the far-infrared spectra of molecules with inversion and *pseudo-* rotational vibrations.

The Optical and Infrared Laser Group has applied a variety of modern spectroscopic methods to the study of fundamental problems in physics. These relate to nonlinear effects in high-resolution atomic and molecular spectra in the visible and infrared, and to the measurement of absolute frequency in precise spectroscopic studies and in new definitions of time and length standards.

Visiting scientists working in the laboratory included Dr. Thomas B. Malloy, Jr., Texas A & M University, and Dr. Toyotoshi Ueda, University of Tokyo.

RICHARD C. LORD

SUMMER SESSION

The economic recession had its effect on the 1970 Summer Session. There was a pronounced decrease in the number of registrants in the Special Summer Programs designed to give outside professional people

opportunities to keep pace with advances and trends in their fields. However, unlike many other colleges and universities, we experienced only a minor decrease in enrollment in the regular summer academic session.

SPECIAL SUMMER PROGRAMS

Of the 70 programs planned for the 1970 session, 10 were cancelled because of projected low enrollments. Twenty-three of the remaining 60 were operated with quite low registrations. There was a total registration of 1,809 in the 60 programs compared with a 1969 registration of 1,935 in 45 programs. When one unusual program for dental faculty (158 registrants) is excluded, the average decrease in enrollment per program, from 1969, was 35 per cent. This percentage decrease does not truly reflect the decline in outside interest because 10 of the original programs were cancelled.

Historically, the registration has fluctuated with changes in the economic climate, so the decreased attendance in 1970 can be attributed primarily to the economic recession.

REGULAR SUBJECTS

Only a limited number of regular academic subjects are offered each summer. The 1970 registration of 2,185 represents a small decrease from the 2,241 in 1969. Graduate students continue to comprise about 85 per cent of the student body.

CONFERENCES

This summer three large conferences were held at M.I.T.

Professor Daniel Roos and Dr. Edward E. Newman of the Department of Civil Engineering organized a conference of The Users Group of the Integrated Civil Engineering Systems (ICES). About 200 attended during the period from June 17-18.

Dean Sanborn Brown and Mr. Michael Baram served as Institute sponsors for an International Humanist Conference directed by The Ethical Society of Boston, held from August 2-9, with approximately 500 registrants.

From August 17-21, the Institute was host to the Tenth International Conference on the Physics of Semi-conductors, under the sponsorship of the International Union of Pure and Applied Physics. Professor Benjamin Lax of the Department of Physics and Director of the National Magnet Laboratory was Chairman. Approximately 900 people attended the meeting, which was held from August 17-21.

JAMES M. AUSTIN

URBAN AFFAIRS

BOSTON MODEL CITIES

Since 1968, M.I.T. has cooperated with a group of Boston area colleges and universities assisting in the development of a higher education program under the auspices of the Model Cities Agency in Boston. In February, 1970, the Higher Education Program began offering courses to 125 students from the Model Cities area. Although no M.I.T. faculty members are teaching in the Model Cities Community College Program, Model Cities students have begun a course of study in the Unified Science Study Program (U.S.S.P.) in the Education Research Center at M.I.T. The Institute is continuing its cooperation with the Higher Education Program of Model Cities as well.

In 1970, the Institute provided facilities and technical assistance for an eight-week program of curriculum and policy development for the Model Cities Community College, which involved over 120 students, faculty and staff planners, creating courses of study and experiment designed for community needs.

Starting in the fall term of 1970-71, nine Model Cities students enrolled in the special science program at the Institute and are working in that effort with 30 M.I.T. freshman and students from the University of Massachusetts at Boston and the North Shore Community College.

The relationships with Model Cities evolved under the direction of Paul E. Gray, Associate Provost, until December, 1970, and subsequently have been continued by Louis Menand, Assistant to the Provost.

M.I.T./WELLESLEY UPWARD BOUND

The M.I.T./Wellesley Upward Bound program is a multi-racial, multi-ethnic educational program for Cambridge high-school aged youth. Now into its sixth year the program serves 60 academically promising girls and boys who have low achievement aspiration and who come from low-income families. The goal of the program is to motivate these youngsters to attend college and to additionally provide them with the necessary academic and social skills needed to succeed in college. To a very large extent the program is influenced by the research done by Kurt Lewin and his associates, particularly in the area of goal setting or "level of aspiration." We have successfully operated on the assumption that ego growth and academic performance are closely related. Not only does a growing ego need to experience success but it will develop more strongly, in both a personal and a social sense, in a warm personal but structured environment. This development can be manipulated through intervention outside of the family and the school. Based on the above general assumption Upward Bound represents such a controlled field

intervention. It has established that the effects of failure can be reversed by presenting the child with real success and that further success leads to an increase in the child's level of aspiration. In this process the people around the student, fellow students, teachers, other program staff, play a crucial role because what he thinks he can do is dependent on what they think he can do. Consequently his perception of his abilities, and therefore what he will try to accomplish, is to a large extent determined by the program staff, who are often the first and only people to see real academic promise in the younger.

THE SUMMER PROGRAM

The Summer residential program is designed to provide the student with an intense academic and social experience. Classes are team taught by experienced high-school teachers and Wellesley College and M.I.T. students. Each student carried three classes which met for 50 minutes each, five days per week. Classes were small and of a seminar nature. Each student was required to take one math and one humanities course and to select a third course from offerings in either. Humanities offerings included reading and writing, race relations, China, lyrics, drama, moral philosophy, anthropology, biology, and college study skills. The mathematics program included four courses: an enrichment section for students who were going to take algebra II, geometry, or math IV; a review section for students who had done poorly in algebra II, geometry, or math IV; an E.R.C. calculus course — a laboratory and computer assisted course in calculus designed by E.R.C.; and an algebra I section involving half of the total student enrollment. This section was subdivided into two sections: Introduction to college prep math course which was composed of an individualized instruction approach and of an approach using Cuisenaire rods and the Gattegno method. The Gattegno method was used in an intensive exploration of the algebraic properties of members using Cuisenaire rods and other physical materials.

THE ACADEMIC YEAR

The academic year program, while less intense and dramatic, has importance at least equal to 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 militate against his success. To achieve this, the following programs were developed and implemented:

STUDY SKILLS The M.I.T. Upward Bound offices were open four evenings per week from 7:00 to 9:30 for study. Students were asked to spend at least one evening per week at one of these study sessions. Each session was manned by a team consisting of two leaders who were part-

time staff and about four undergraduate volunteers. They worked individually or in small groups with students on problems they were having with their school assignments. The students were encouraged to attend more than one session per week.

TUTORING Whenever requested or needed, tutors were assigned to individual students. Tutors are typically M.I.T. or Wellesley undergraduates who arrange to meet on a mutually convenient and regular basis with the student and then report back to project staff.

COLLEGE COUNSELING

This year the college counseling staff gave assistance to a group of our post-graduates who for one reason or another had not gone on to college last year. Through their efforts, three post-graduates were placed in situations of higher learning. One of these students had been working for a year saving her money and was accepted in a scholarship program at Boston University. Another student had dropped out of the school he was placed into last year and was successfully admitted into a technical college. Finally the last of the three post-graduates had attended a prep-school last year and was placed this year into Northeastern University.

This year's graduating class included 15 seniors. We have been able to place all of them into schools of higher learning. Twelve of these students will be going to four-year colleges. Six of the students will be going to two-year colleges or vocational schools with the intention of transferring into a four-year college. We have placed 18 students into schools.

College Enrollment — Fall 1971

School	*No. attending*
Boston State	1
Boston University	2
Brynam School	1
Clark University	1
Grahm Junior College	1
Hawthorne College	1
LeMoyne Owen College	1
Northeastern University	4
Northshore Community College	3
Thomas Valley Technical School	1
Wellesley College	1
Wheelock College	1
	18

THE SATURDAY PROGRAM

The goal of the Saturday program is to furnish a miniature duplication of the Wellesley summer experience during the fall on Saturday from 10:30 to 4:30. It was desirable to have as much participation by students as possible.

For the Saturday program we had an arts and crafts class which was used by about half of the students who came up on the bus. The class was a popular one for a certain number of students. We had a math class conducted in the afternoon which required the use of physical material. This class was also popular for a specific group of students. Piano lessons were also given to about eight students. The pool was open from 2 to 4 and the gym was open from 1 to 4.

TEACHING PROJECTS

The past year represented a plateau where student initiated activities were concerned. The preceding six years had seen a marked M.I.T. and national growth in student concern for the human environment in which they lived and worked and in the accessibility of social benefits to those less fortunate than the typical college student. This concern occurred at M.I.T. perhaps a little earlier than at other institutions, beginning in late 1964 and early 1965 with the development of tutoring and compensatory academic programs for late elementary and high school students in Boston and Cambridge. One of the first of these efforts was Tutoring Plus, a tutoring project administered by M.I.T. undergraduates and utilizing the facilities of the Cambridge area nearest to M.I.T. In subsequent years, this project received funding as a Talent Search program funded by the United States Office of Education. Since 1969 it has been funded by the M.I.T. Community Service Fund and is now a wholly parent- and student-operated project serving over 150 neighborhood children in a one-to-one tutoring relationship, with ready access to the local Roberts elementary school, and with six years of growing respect among the residents of the community it serves. It has recently been incorporated so that the organization can receive funds. M.I.T. and community persons serve on the Board of Directors.

Begun as the Science Day Camp in 1965 at the same time as Tutoring Plus, the M.I.T.-Wellesley Upward Bound Program has become a major educational project among low-income students in the City of Cambridge. Much credit for the development and subsequent success of these two programs, and in particular Upward Bound, goes to Michael Efron '65. Mr. Efron continues his relationship on a part-time basis with Upward Bound having completing an M.I.T. degree at the Harvard Graduate School of Education (1966). He is now working in the clinical psy-

chology Ph.D. program at Harvard. Through Mr. Efron's personal interest and close association with the families and children in Cambridge there has evolved a remarkable continuity in this project and a full acceptance of its mission and operations by the Cambridge high schools.

Stemming from these efforts in 1968 was a further effort in which Mr. Efron played a significant role, the Teaching Assistant Program. This project concluded its third very successful year in June, 1971, after having had some 45 M.I.T. students teaching part time in Rindge Technical High School in Cambridge during the 1970-71 academic year. This program, formally known as Institute Seminar 211, offers 12 units of credit for a seminar at M.I.T. and up to five hours of actual teaching in one of the Cambridge high schools. During this past year Dr. Louis Menand, Assistant to the Provost, has been responsible for this project. It was under the immediate supervision of James McIntyre, Research Associate in the Sloan School, with the assistance of Mrs. Janet Efron. This seminar at M.I.T. met weekly throughout the year and had high school faculty participation in it. These high school faculty members have shown a keen interest in the teaching assistant program and have made use of library and other M.I.T. facilities important to them in their professional work. The project has made every effort to increase the interactions between school personnel and persons and resources at the Institute.

While there have been top level changes in school administration in Cambridge, the Teaching Assistant Program has continued to receive strong endorsement from the school Superintendents and the Principal and Assistant Principal of the school involved. Some of the M.I.T. students who have worked in this project have also worked with some of the same students in the M.I.T. Upward Bound Program. Some of the students have subsequently gone to the Harvard Graduate School of Education and have returned to these same classrooms for their practice teaching experience. In short, the Teaching Assistant Program forms part of a growing interest in teaching and in education among M.I.T. undergraduates.

LOUIS MENAND

URBAN SYSTEMS LABORATORY

The third year in the brief history of the Urban Systems Laboratory was one of intense and productive project activity. After two difficult years of startup activity, the Laboratory was able to settle down and concentrate on the execution of the projects which were initiated during

the startup period. The dynamics of the Laboratory were set in motion with a continuous flow of projects in varying stages of initiation, execution, and phase-out.

The administrative and operational machinery of the Laboratory also became well established and functioned smoothly during the year. A new and attractive headquarters complex was developed through space renovation in Building E-40. While the Laboratory will continue to rely heavily on faculty and students from the participating academic departments to staff the research projects, modest steps were taken during the year to associate with the Laboratory a small core of professional and technical staff members who can give full-time attention to the operations and projects of the Laboratory.

Having provided the funds to help launch the new Laboratory, the Ford Foundation made a new grant to help continue its activities for an additional three years. While the Laboratory must depend on contract research, largely from government agencies, for project support, the experience of the first three years demonstrated that a component of funding from private sources is essential. Thus the Ford grant, which we hope to augment from other private sources, was a vital development in moving ahead.

The Laboratory was conceived of as mission-oriented, in that technical research teams affiliated with it assume the responsibility to involve relevant industry or community organizations in such a way that project results will be successfully implemented into the appropriate environment. The Laboratory itself serves the affiliated projects and programs while maintaining a low profile. Each project has its own identity and seeks its own visibility. Detailed reports on individual projects can be found in departmental and school reports, or in the Laboratory's annual report. Accordingly there follow only brief highlights of typical projects which the Laboratory has served and assisted.

The Technology, Race and Poverty Project, supervised by Professor Frank Jones, is working with a community group in the Roxbury section of Boston which was designated as developers for a housing rehabilitation project. To facilitate providing technical assistance to the group, a non-profit corporation, the Community Assistance Corporation, was formed; its members, directors and officers being made up of project staff. The corporation will be an important experiment in modes of involving staff and students in community action without involving the Institute.

The Transportation and Community Values Project, under the direction of Professor Marvin Manheim, continued as one of the largest and most productive projects in the Laboratory. The goal is to find ways to

plan, locate, and design transportation facilities which are responsive and sensitive to community and environmental concerns. In addition to national support, the project was given a contract by the California Division of Highways to field test the new methods on an actual urban highway project in Los Angeles.

The Systems Dynamics Group, under Professor Jay Forrester, continued its work on urban dynamics and worked on models of the dynamics of a number of social systems on national and global scales. Work was initiated on the structure of the health system of the United States, and the drafting of a national urban policy. The work of the Group attracted support from many sponsors, including the Independence Foundation, Club of Rome, Volkswagen Foundation, and the Permanent Charity Fund.

Through a contract with the Boston Model Cities Administration, faculty and students continued to assist in solving Model Cities problems. An information and record-keeping system with computer capabilities was developed for the Model Cities Health Clinics. A seminar series for M.I.T. and Model Cities staff dealt with such problems as industrial development, transportation, Federal funding, and accounting.

The Urban Geometrics Project, under the direction of Professor Charles L. Miller, was awarded a major grant from the National Science Foundation. The project is developing a geo-based information system which has powerful computer manipulation capabilities. In addition to handling precise geometry associated with property surveys, the system can handle attributes of all kinds such as tax records and detailed utilization. Field testing on a section of Boston is underway.

The automated Guideway Transport Project, under the leadership this year of Professor David Wilson, continued its research on a variety of technical problems associated with automated and guideway transport systems, and undertook a technical study of innovative transport systems for a proposed new community in Puerto Rico.

The Laboratory provided extensive staff support during the year for special studies of rail transportation in New England, particularly for high speed service between Boston and New York. The studies were performed for the New England Regional Commission and the New England Governors' Conference.

The Mobile Home Industry Project, under the supervision of Professor Arthur Bernhardt, continued with chief emphasis on the economic and legal aspects, including zoning and taxation policies. The project has attracted the interest of the U.S. Department of Housing and Urban Development and contract support is being negotiated.

Project CARS, the development of a computerized Dial-A-Ride sys-

tem under the direction of Professor Daniel Roos, was concluded at the end of the year. The operational computer programs and related system components for a computer controlled fleet of twenty to thirty minibuses were completed and delivered to the Urban Mass. Transportation Administration. The Dial-A-Ride concept is gaining wide acceptance, with many manual systems being introduced. Future expansion to computerized systems is anticipated if the manual systems are well run and hence successful.

A new project on Alternative Development Strategies for the Boston Region was initiated under the direction of Professor Lloyd Rodwin. A major interdepartmental project with large scale external support is intended. The project will focus on the critical factors which shape the pattern of urban development and over which public policy does or could exert maximum leverage.

The Urban Transportation Laboratory Project under Professor Manheim is developing a set of instructional tools designed to acquaint students with the interrelationships between transportation technology and social factors. A series of computer simulation models are being constructed which allow students to conduct laboratory experiments in urban transportation systems analysis. During the year the project received a major grant from the National Science Foundation.

The Urban Transportation Program administered by Henry Buck and funded through the Section 11 grant program of the Urban Mass Transportation Administration continued to support a large number of research initiation efforts. The program staff also participated in work on the national transportation needs survey being conducted by the Office of the Secretary of the U.S. Department of Transportation.

Among those who contributed their talents to the work of the Laboratory were Mr. James Sullivan, formerly City Manager of Cambridge and currently City Manager of Lowell, who served as Senior Research Associate in the Laboratory and conducted a seminar series on the problems of the cities. Dr. Frank Davidson, formerly President of the Institute for the Future, served as Senior Research Associate, conducted a seminar series on Macro-Engineering and participated in a number of research projects. The Laboratory was host to a large number of visitors during the year and served as a contact point for many interactions between the M.I.T. community and the urban community at large. Many of the activities of the Laboratory go unreported due to their often informal and ad hoc nature. Yet such activities, are significant contributions of the Laboratory. The Laboratory is a loose federation of many individuals and groups and reflects the wide diversity of values and activities one finds in the city itself. Be it providing space for the student run Urban

Vehicle Design Contest, a channel for an interdepartmental proposal, funds to assist a student, a forum for a community leader, or assistance in contract management, the role of the Laboratory is to help the many at the Institute who are dedicated to improving the quality of urban life in our nation.

CHARLES L. MILLER

WELLESLEY-M.I.T. EXCHANGE PROGRAM

This year the Wellesley-M.I.T. Exchange program completed its third year. The number of M.I.T. students taking subjects at Wellesley increased from 100 in the fall of 1969 to 152 in the fall of 1970 and from 225 in the spring of 1970 to 270 in the spring of 1971. The number of Wellesley students taking subjects at M.I.T. was 270 in the fall of 1970 and 319 in the spring of 1971.

The calendars for the academic year at Wellesley and the Institute were brought closer together this year, but the uncertainties concerning the January Independent Activities Period may have had an adverse effect on the participation of M.I.T. students in the Exchange.

M.I.T. students from all the Schools took part in the Exchange; in the spring of 1971, 8 per cent were from Architecture and Planning, 29 per cent from Engineering, 12 per cent from Humanities and Social Science, 6 per cent from Management, 28 per cent from Science, and 17 per cent were freshmen and undesignated sophomores. At Wellesley 50 per cent of our students took a subject in the humanities, 7 per cent in the foreign languages, 37 per cent in the social sciences, and 6 per cent in the sciences. At M.I.T. 21 per cent of the Wellesley students took a subject in Architecture and Planning, 7 per cent in Engineering, 61 per cent in Humanities and Social Science, 1 per cent in Management, and 6 per cent in Science.

ROBERT A. ALBERTY

SCHOOL OF ARCHITECTURE AND PLANNING

In his 1965 and last Report, former Dean Pietro Belluschi emphasized the need for more effective and flexible education in architecture and planning. The past year marks the termination of his successor's deanship in the School; it is appropriate now to review the principal developments of the last six years and to offer some interpretation of the present status of the School compared with that earlier milestone.

Following a long period without changes at the top, recent years have seen the appointment of new chairmen for the two departments. Professors Donlyn Lyndon of the Department of Architecture and Lloyd Rodwin of the Department of Urban Studies and Planning now carry the responsibility for leadership toward the future; they will be supported by a dean who remains unidentified at this writing. The Department of Planning's new name, the Department of Urban Studies and Planning, testifies to a broadening of the scope of planning education.

The School has encouraged the establishment of a new and autonomous agency, the Center for Advanced Visual Studies, with Professor Gyorgy Kepes, now an Institute Professor, as its Director. The early generation of the Center's Fellows, including Jack Burnham, Ted Kraynik, Otto Piene, Vassilakis Takis, Harold Tovish, Wen-Ying Tsai, and Stan Van Der Beek, has determined its initial character and purpose. The activities of the Center are reported directly to the Provost.

Both the Departments of Architecture and Urban Studies and Planning have become deeply committed to undergraduate education; each now offers a four-year S.B. with a major in some aspect of its field. The degree M.Arch. now relates to a two-year graduate program, and the Ph.D. is rapidly becoming the predominant program in Planning.

The last six years have been a period of growth. Faculty retirements and resignations have been more than offset by the recruitment of distinguished new scholars on whom the quality of the School will increasingly rest: Professors Wayne V. Andersen, John R. Harris, Leon B. Groisser, Donlyn Lyndon, Lisa R. Peattie, William L. Porter, Martin Rein, Chester L. Sprague, Minor White, and Waclaw P. Zalewski. Behind them is an additional cadre of recent appointees as professors, instructors, and lecturers: Edward B. Allen, Julian Beinart, Arthur Bernhardt, Giancarlo de Carlo, Robert M. Fogelson, Ralph A. Gakenheimer, Robert Goodman, Justin Gray, Jonathan W. Green, Imre Halasz, Hans H. Harms, Philip B. Herr, Timothy E. Johnson, Langley C. Keyes, Rosalind E. Krauss, Richard Leacock, Tunney F. Lee, Karl Linn, Patrick Moreau, Nicholas P. Negroponte, Edward R. Pincus, Mary C. Potter, Donald A. Schon, John A. Steffian, Lawrence E. Susskind, George C. Thomas, Richard C. Tremaglio, John F. C. Turner, Ronald A. Walter, Jan Wampler, and Judith G. Wechsler. Special efforts are being made to increase the proportion of both women and members of minority groups.

Increase in the magnitude of the teaching programs can be measured by the factors in the following table:

	1965	1971	% increase
Degrees Awarded			
Architecture	32	80	150
Urban Studies and Planning	19	32	68
Total	**51**	**112**	**119**
Majors Enrolled			
Architecture	135	292	116
Urban Studies and Planning	58	161	178
Total	**193**	**453**	**134**
***Registration Units**			
School of Architecture and Planning	9,000	19,057	112

* Index of teaching load from "Tucker" Reports.

With a larger faculty and student body, new educational and research programs, and greatly increased budgets, the School has generated new space needs, which so far it has been possible to meet only in part. These needs have at least doubled during the period under review and, if

present growth continues, will in a few years triple from the 1965 base. Some physical expansion of the space used by the departments has indeed occurred. Portions of the programs have been placed in Buildings W31 and E21, causing unfortunate separation and isolation of certain groups. Computer activities and faculty offices have benefited by the assignment of space in Building 9, conveniently adjacent to Building 7. Further adjacent expansion may be possible when the completion of the Electrical Engineering Building releases space in Buildings 3 and 10. If this proves not possible or adequate, the School must consider a move to East Campus, either by altering Building E40 to its use or by relocating in a new facility, or by a combination of the two. These alternatives, and others, are treated in detail in the report *APSS 1969,* which has also been mentioned in previous Reports of the President.

So much for the basic facts of growth. There have also been remarkable changes of style and content.

No sector of higher education has been immune to the changed attitudes of university students which have generated so much conflict and polarization on our campuses in recent years. Episodes of maximum stress have effectively prevented normal university activities during short periods. During intervening times, however, this School has benefited by the new level of initiative and participation of students. In what Professor John T. Howard acknowledged in 1968 could be called a student revolt, graduate planning students liberalized the Master of City Planning curriculum to eliminate specific subject requirements. Architecture students launched a series of "environmental demonstrations" — drafting room mezzanines, an exhibition memorializing Martin Luther King, another exhibition, *Form and Use in Architecture,* in the Hayden Gallery, and a construction in the lobby of Building 7 — each of which achieved a higher level of refinement than the preceding. In each department students now participate responsibly with faculty as members of committees or task forces to modify curricula, recruit or promote junior faculty, and arrange for publications, lectures, and seminars. Black students are active in recruitment of new students from minority groups. These activities no longer have the character of confrontation.

Participation extended as intervention in the real problems of communities, especially for population groups short-changed by corporate prosperity or neglected by government policy, fosters the possibility of entirely new roles for the university and new experiences for its students and faculty. As we look back over recent years, it is seen that we are expending much effort in learning how to manage these field projects without committing the classic errors that antagonize clientele and diminish respect for academics. Architecture and planning must be

measured by their effectiveness in actually changing the social or environmental milieu. Students and faculty alike will no longer confine themselves to paper exercises intended to simulate change processes; they suspect the processes are themselves in need of change.

Six years ago two of our senior faculty members, Professors Aaron Fleisher and Albert G. H. Dietz, each a professional with a foot in another discipline, were taking the first steps to introduce computational aids to the problems of planning and architecture. Graduate students and young faculty lacked at that time the background and motivation for information processing. Skepticism and even ridicule for the computer as a tool useful in design and policy problem-solving were occasionally expressed. However, during the intervening years the computer has slipped into our programs; there has been created a significant level of computer-based research and teaching. This has happened gradually without any massive and general dedication. Young faculty members have become interested; they have recruited others and through their individual initiatives hardware has been assembled. Software achievements such as URBAN 5, DISCOURSE, and the ARCHITECTURE MACHINE are making the School an important center for development of computer aids to complex environmental decision making, certainly one of the most innovative in the environmental design fields.

These changes of style and content — student participation in governance, community intervention for academic credit, and partnership with the computer — would be conspicuously evident to any returning 1965 alumnus. On top of these qualitative changes it is useful to summarize briefly the specific new programs that have become a part of the School's panoply. From the Department of Architecture have come innovative contributions to the general education of M.I.T. students, toward understanding and interpreting the environment in visual terms. The appointment of Professor Wayne V. Andersen in 1964 was the key event that marked the beginning not only of a new series of humanistic studies in the history and criticism of art, but also of a much more potent general program in the Visual Arts under the jurisdiction of the Provost, including concern for the art collection, periodic exhibitions, and an upgrading of the general M.I.T. environment in collaboration with the Planning Office and various consultants and committees.

Also dating from that year was the inauguration of the program in creative photography under the leadership of Professor Minor White, who has recruited a cadre of teachers and an extraordinarily devoted student following for an art peculiarly appropriate to the technical proficiency characteristic of M.I.T. citizens. The next step in the expressive arts has been the program in film, begun in 1968 under

Professor Edward R. Pincus and continued with new resources and equipment by Professor Richard Leacock in 1969.

Through the Department of Urban Studies and Planning the School this year has embarked on a new undergraduate program, the S.B. in Urban Studies, conforming to all the General Institute Requirements for the S.B. and aimed at furnishing preprofessionals in many areas with a grasp of urban conditions and challenges. This program is supervised by Professor Ralph A. Gakenheimer.

The response of the student community to all these new offerings has been extraordinary and has offered persuasive evidence that such fields of study have validity as part of M.I.T. education and that the teachers who represent them have been well-chosen.

At the other end of the pole, advanced professional studies have gradually developed toward certain specializations: in Architecture, towards building systems, urban design, and design for developing countries; in Urban Studies and Planning, towards social policy (race and poverty), city design, developing areas, and quantitative methods. A certain duplication and overlap is evident, testifying to the truism that professions are being redefined in terms of current world problems which they all face. The area of urban design/city design has been the subject of intensive collaboration between faculty and students in the two departments, which will surely lead to new and richer combined study possibilities.

On the other hand, the work in Architecture under Professor Horacio Caminos on housing and community design for developing areas has remained quite separate from the program called SPURS, originated by Professor Lloyd Rodwin. SPURS is a special one-year non-degree program for people who will play important roles in development policy in "third world" countries. Communication and consistency, however, have been maintained, largely due to the contributions to both programs by Mr. John F. C. Turner, one of the first persons to regard urbanization by squatter settlements as a solution rather than a problem.

The Department of Urban Studies and Planning is presently inaugurating another special non-degree program aimed at the education of potential policy leaders coming from urban neighborhoods that have had difficulty optimizing the benefits of urban life. This Community Fellows Program is a daring venture which, if successful, will become a valuable model of an extended educational role for schools of planning and related professions. The program is being supported primarily by a grant from the Rockefeller Foundation.

During the summer and fall of 1970, at the urging of former Associate Provost Walter A. Rosenblith and with sponsorship from the Ford

Foundation Grant for Urban Affairs, the two Departments of the School engaged in a collaborative self-evaluation whose basic purpose was to determine the relative roles of the departments and the scope of their mutual reinforcement and to chart the future of the School in some detail, so that support could be sought for the various areas the School might wish to develop. The groups working on this study were under the chairmanship of Professor William L. Porter and constituted a wide representation of senior faculty, junior and part-time faculty, and students.

This study, which takes the form of a proposal inviting sponsorship by the National Science Foundation, is unquestionably more searching than any comparable effort ever attempted within the School. It measures the present shortcomings of traditional modes of teaching and practicing architecture and planning and proposes a new intellectual platform to coordinate the interests of the two departments toward a more effective engagement with contemporary social problems. To quote from the report, "we wish to develop a framework in which we can explore, in conjunction, new ways of educating students, new modes of professional practice, and new ways of conceptualizing and learning about reality."

The study group was faced with the need to bring order into the School's rapidly expanding fields of interest. A central "trivium," in which all students would participate before engaging in more specialized studies, has been proposed. Its three parts are People and Environments, Systems and Institutions, and Policy and Design.

In the report, each department in turn sketches its historical background and its present posture with respect to the proposed trivium. The two Departments see these components in somewhat different terms, but it is clear that each would accept reorganization of its basic conceptual and knowledge structure according to that format. Planning sees that its developing concern with social policy needs a solid base in the three proposed areas; Architecture, faced with the need to look beyond "design objects" in favor of the notion of "artifacts," perceives that the meaning of artifact for the professional can only come through a rich understanding of the three study groupings proposed as a core.

What would be the means to achieve a high level of knowledge in this three-sided structure? The task is seen as requiring interdisciplinary effort in four related categories: research and curriculum development; fieldwork; new methods, groupings, and clients; and information and media.

New curricular capability is needed. In the area of People and Environments information is needed regarding the satisfaction or dis-

satisfaction of social groups with their environments and with change processes, while at the microlevel there is concern for psychological and physiological interactions and the ways people use the environment. Under Systems and Institutions we need to identify the latent and actual as well as the manifest and professed functions of organizations, their impact on people, influence on resource allocation, and quality of service delivered. Under Policy and Design the greatest need is probably for more sophisticated feedback enabling us to evaluate the true success or failure of policies and projects. We also need skill in simulating environments and policies, and in ways to give users more access to information and opinion used by professionals.

Work along these lines will open up research in specialized fields the School should explore, and a number of these are given as examples: national policies to influence patterns of urban growth; the overall management of urban construction; and the development of new communications and media.

The growing importance of fieldwork requires financial support and administrative strategies to see that it is adequately supervised and monitored and intimately connected with teaching and research. Conventional academic systems penalize the person who moves into field-related activities, particularly with newly-organized and poorly-funded community groups. A number of separate modes for fieldwork are described in the proposal, and a recommendation is made for setting up a board that would be responsible for policy-making, staff, and management functions. In order for such a group to operate on behalf of the School rather than separately for the two Departments, it should be lodged in a new entity, a center for the human environment, which would organize fieldwork, in-house research, and the development of the new educational trivium.

New methods, groupings, and clients involves the development of new modes, methods, and physical settings (including off-campus) for teaching. It also involves encouraging faculty and students to cluster about subject areas, forming groups (often interdepartmental). Such persons would enjoy a certain degree of autonomy in student counseling, recruitment of faculty, structure of coursework, initiation of research, and provision of special colloquia in their subfields. There is a further commitment to serving new educational clients, mainly through special non-degree course programs for population groups not normally represented in the M.I.T. student population, such as SPURS, the Community Fellows Program, and others that are under consideration.

The topic information and media raises the whole question of acquisition and organization of information in relation to library facilities

which are already overstrained in the effort to make available the large amount of non-book material that is accumulating. New informational techniques, statistics, languages, games, films, field observations, and projects requiring large information bases are constantly being introduced. Experiments with mixes of traditional media will need special facilities for multiple screening of slides, films, and video. Besides student and faculty training in the use of data manipulation and devices, we should develop techniques to enable the relatively unskilled to represent environments and to manipulate the representations.

The Porter group has unearthed a wealth of opportunities for work of great cultural importance and social relevance, phrased in terms of the capabilities of the entire School rather than from the outlook of the Departments separately. Administrative arrangements will have to be found for managing the proposed Center for the Human Environment in such a way that it does not become in itself a department competing with the others for resources. Care will be needed in developing the interdepartmental character of subject-matter groups. These new entities within the School will expand the responsibilities and concerns of the School's Dean, who will be required to preside over a more complex structure.

All of this should in no way downgrade the professional development of architects and planners. On the contrary, the potential enrichment of our educational environment will add enormously to it. The departments will maintain the initiative in professional matters and the control of quality in their faculty and programs in line with the traditional structure of M.I.T.

LAWRENCE B. ANDERSON

DEPARTMENT OF ARCHITECTURE

The past year has been for the Department of Architecture a year more of consolidation than of exploration and more of assessment than of innovation. The Department has emerged at the end of the year better prepared than in the past for major developments in the field and in its pattern of education.

Immediately following the painful and ultimately health-giving traumas of the spring of 1970, the School of Architecture and Planning undertook an examination of its future that has proved very helpful. The study, resulting in a major proposal for external funding, was initiated during the summer by faculty and students from both the Department of Architecture and the Department of Urban Studies and Planning under sponsor-

ship of the Ford Foundation grant for Urban Affairs. During the fall and winter draft documents were reviewed extensively and completed. While no formal submission for funding has yet taken place, the proposed program and its preparation have articulated many of the Department's most urgent intentions. The development program described in the Dean's summary reaffirms an intention to pursue those studies that will lead to a fundamental reordering of the professions with which Architecture is related.

An attempt has been made to understand these principles both in the subject matter of the Department and in its conduct. Research and teaching within the professional programs of the Department continue to be focused primarily on the means whereby the systems of environment-making can be more responsive to concerns that are personal or that are under-represented in the established procedures for design and professional services. Examples are Professor Chester L. Sprague's work with the Alaskan Indians and the Navajoes, Professor Robert Goodman's work with Low Cost Housing, Inc. in the South End, Professor John A. Steffian's work with community groups in Allston and Brighton, Professor Jan Wampler's work at Columbia Point, and Professor Maurice K. Smith's persistence in the study of forms that accommodate unprogrammed action. However much these may vary, they share in common a disaffection with the prevailing assumptions that constrain the theory and practice of making places that people live in and use. These, and others of the faculty, are determined to develop examples of the ways in which the built environment can be more richly configured, more genuinely gratifying, and more equitably enjoyed than it presently is.

Reordering the ways in which our society makes its environment most often implies that decisions should not be concentrated where they have been. It is far more likely that a diverse and supportive environment will come about through responsible diffusion of environmental decisions than through their concentration within agencies and offices that seem very often to limit their attention, standardize when they need not and be careless where their constituents may wish to care. To provide people the power of understanding, we must clarify and expose to many the issues and habits embedded in decisions about the form of both, the immediate environments we use and the more extensive ones that surround us. Such a context offers new and widely varied opportunities for professional involvement.

The Department of Architecture as an organization may also have centralized decisions unnecessarily. Some of its members have suggested that they have over-extended, as architects are prone to do, an informal, personalized type of decision making that may have worked well for a

small Department with established intentions. This may no longer be appropriate for the much more numerous, more complicated and diverse assembly that the Department has become in the past several years. This year a panel of faculty members, Professor Horacio Caminos, Leon B. Groisser, John R. Myer, Robert O. Preusser, Maurice K. Smith and Richard C. Tremaglio, joined at the end of the spring term by several students, worked very hard to give full consideration to issues confronting the Department and to guide its future development. At the end of the year an Educational Council was formed with eight members elected by the faculty to serve as a continuing body for planning and review. Its first meetings are this summer, and it will be augmented by the inclusion of six students at the beginning of the fall term.

Complementing these Department-wide reviews will be greater recognition of the clustering of interests within the faculty. Many of the faculty are now defining specific areas of common concern in order to form groups that will have a measure of operating autonomy and establish a context whereby those students and faculty most immediately concerned with specific issues can either determine choices directly or advocate effectively for their outcome.

At present there are four such groups already visible: Environmental Design, comprising the faculty in the Department that are concerned with urban design and those in the Department of Urban Studies and Planning who have been identified with city design; Building Technology, comprising members of its faculty in the areas of structures, building process and environmental controls; Computer Studies, with members from both Departments who have developed computer programs and hardware assemblies that will serve the interests of architecture; Visual Studies, including those faculty from the Department who have been identified with subjects in photography, film, and visual design. There are several other clusterings which have previously existed, such as history, theory and criticism of architecture and the arts, or which are now being articulated, such as a group concerned with built form studies or another that is principally interested in architecture as an instrument of social processes. Specific programs of research and teaching will be proposed by these groups and reviewed by the Council. Students will be invited to chart their own interests within the Department in these terms or to propose combinations of subjects that reflect their particular concerns.

Those groups that have already formed have proven to be fertile sources of innovation. They are voracious, therefore, in their need for space. For example, the computer group has more than filled the space made available to them two years ago and must now have more in order to

accommodate rapidly proliferating users and machines. The building technology group has devised a program that demands more extensive laboratory space and a (long avoided) reorganization of shop facilities and management. The various visual studies programs have been expanding in their use of space. An excellent new facility for film production and viewing has been provided in the ground floor of building E21. Most of the visual design subjects, now heavily enrolled, also take place in E21. An additional new graphics facility has been developed in Building 5 by Leon Shiman and Ron McNeil to make possible the various forms of multiple graphic reproduction, both conventional and photographically-dependent.

Meanwhile, simply to accommodate the continuing growth in undergraduate and graduate enrollment, the Department was forced this year to abandon use of its common exhibition and meeting-room in order to convert it to studio space and to remove to a separate warehouse building the great store of archival material that has been accumulated from past programs. The large space thus released was used on an emergency basis as a studio for architecture and visual design subjects. The absence of decent spaces to show work and to come together in Department-wide meetings has been a hindrance, but the Department now hopes to reclaim the entire fourth floor area surrounding the dome of Building 7 as a lounge, exhibition area, and meeting place.

The difficulties imposed by inadequate, dispersed, and unsatisfactory space were noted especially during the National Architectural Accrediting Board visit this year. While granting professional accreditation for the regular five-year period and generally commending the Department's preeminence, the Board commented in a June report on the need for more and better space, for a Department-wide Council of the sort that has now been established, and for more effective counseling procedures, a problem that has since been taken under review. This latter is another instance wherein the administrative procedures of a smaller and simpler Department have been less than satisfactorily adapted to our present condition, one which involves many undergraduates with indeterminate professional objectives.

A further positive development in this year's procedures has been the important role that students have played in the conduct of the Department. Tova Solo's weekly notes of information and comment contributed enormously to the life of the Department. Isabel King took responsibility for the weekly calendar and the innumerable arrangements that attend meetings and lectures. Francis Fleetwood solicited, edited, and brought to press the contents of three fine issues of *Research*, reporting important studies within the Department. Other graduate student staff members

assisted in instruction or on research projects ranging from assistance to a Navajo community school to special studies prepared in the context of the M.I.T. Planning Office Northwest Area Study. A student project of special importance was the building of an extensive, steel-framed platform, lounge, and stair system in the lobby of Building 7. Designed, negotiated, and largely executed by Bill Bertsche, Karen Vogel, and Brandt Andersson, three students in their first year of design, this project has been one of the most successful of the Department's efforts to have students learn the full range of organizational and logistic processes necessary to intervene in the public life of an ongoing institution. Much of the construction work was undertaken as a project in the building process subject. Materials were provided from the IBM Fund and the project received the attention, approval, and support of the Administration. The students responsible for initiating the project have undertaken to assist with the management of its use, to evaluate its success as an experiment, and to guide next year's class in modifying or disassembling the structure, should that be warranted.

Many other instances of student initiative and involvement with concrete problems have taken place within the context of the Community Projects Laboratory. Its activities, under the direction of Hans H. Harms and supported by the President's Fund for Community Affairs and by Federal work/study grants, have ranged from assistance to schools in the development of environmental education to the conduct of a comparative study of innovative modes of housing rehabilitation in the Boston area. While the Laboratory has not yet attracted the level of research support that one might wish, it has become an important means for student access to problems that specially interest them. One project, the Saranac and Newcastle Court Rehabilitation, originally funded as a student project by C.P.L., has become an important component of an Urban Systems Laboratory program, Technology, Race and Poverty.

These few citations render a less than full account of the significant developments within the Department. The excitement of the new program in film with Professors Richard Leacock and Edward Pincus has not been mentioned, nor have the rigors of a study into industrialization of the building process for production of university buildings, conducted by Professors Dietz, Catalano and others for the State University Construction Fund of New York. These, and many others, have been of fundamental importance in defining the scope of the Department's activities.

The Department has distinguished itself by faculty honors and publications. Notable among these have been the granting to Professor

Myer of Fellowship in the American Institute of Architects; the award to Professor White of a Guggenheim Fellowship and an Honorary degree from the Maryland Institute of Art; and the designation of Professor Dietz by the Society of Plastic Engineers to be recipient of the International Award in Plastics Science and Engineering. Professors Goodman and Krauss have each been awarded Guggenheim Fellowships for the coming year.

The Bemis Fund this year supported several important visitors to the Department. Gunter Nitschke visited from Princeton University once a week during the spring term to conduct a seminar in Japanese architecture. His lectures and projects were extremely popular, adding to the range of excellent offerings in history within the Department. Giancarlo de Carlo returned again twice this year to organize and conduct, with Julian Beinart, a study of alternatives to the prevailing pattern of space organization in urban universities. The major thrust of their work was an exploratory seminar during the January Independent Activities period. Colin St. John Wilson visited from London three times during the year to work with students in their final year of the B.Arch. program on their fall term projects and their theses. Robert Kliment visited from New York during the fall term to direct the second phase in a study by these students of the form and use of Field's Corner, a neighborhood in Dorchester. Others who participated in this studio project were Professor Donlyn Lyndon, Hugh Hardy from New York, and Charles Moore, Dean of the Faculties of Design and Planning at Yale University.

Withal, it is the composition of the faculty that determines the quality of education provided, and there have been this year several additions and changes that should be noted. Julian Beinart and Imre Halasz each joined the Department this year for extended appointments as Visiting Professors, where they contributed well beyond their immediate teaching duties, Professor Beinart as Chairman of the Department Graduate Committee and Professor Halasz as coordinator of thesis preparation in the Bachelor of Architecture program. Jan Wampler served as Assistant Professor in Architectural Design, and Judith Wechsler was appointed Assistant Professor of the History of Art. Professors Johnson, Pincus, Tremaglio, and Bernhardt were each reappointed as Assistant Professors after service in non-professional rank. Leon Shiman, as Instructor, initiated new areas of study in graphics. Reinhardt Goethert, as Instructor, assisted Professor Caminos in the study of housing and settlement design in developing countries. John Terry was appointed Instructor in the film program.

Next year Professors Sprague and Groisser will continue their appointments as tenured members of the faculty. Professor Sprague has

been instrumental in establishing new patterns of research and professional involvement within the Department, especially with respect to minority and disadvantaged clients. Professor Groisser has, as a teacher in structures, as a partner in the development of highly sophisticated computer capabilities and as Head Counsellor to the Department, demonstrated his surpassing ability to make the assessment of facts and the use of reason aids to, but not substitutes for, difficult human judgments.

The Department faces a major transition next year with the retirement of Dean Lawrence Anderson. After 38 years of service to the Department, Dean Anderson is leaving administration and full-time teaching. He will fortunately be returning to teach in the Department next spring, offering again as a teacher that strength of judgment coupled with gentle, discriminating response that has characterized his leadership of architectural education in the United States.

DONLYN LYNDON

DEPARTMENT OF URBAN STUDIES AND PLANNING

During the past year the Department of Urban Studies and Planning helped to prepare a major proposal to NSF for the reorganization of the School of Architecture and Planning. The Department initiated and obtained outside financial support for a Community Fellows Program, and it substantially expanded its teaching and research programs, encouraged a significant and highly responsible increase in student participation in the affairs of the Department, and accommodated a threefold increase in the number of minority students enrolled in the master's and doctoral programs. The Department also initiated a student and alumni newsletter coupled with a successful drive to expand alumni support. These and other changes which are in the offing were made possible by the active help and participation of both students and faculty, and especially by the devoted assistance of Professor John T. Howard, who stepped down last year after serving as Head of the Department from 1957 to 1970. The new Head of the Department is Professor Lloyd Rodwin.

NEW PERSPECTIVES

The School-wide National Science Foundation Task Force, headed by William L. Porter, Professor of Urban Design, spent the summer months and much of the fall term identifying long-term development strategies for the School. Of the many significant proposals made by the Task Force, three were of exceptional importance. The first was a recommendation for increased support of smaller program groups, many of

which would cut across present departmental lines. These groups would have greater autonomy and responsibility for budgeting, designing curricula, and setting degree requirements. The second was to promote new field work opportunities, to provide better management of these activities, and to learn from the experiences of participants by providing for effective reporting and evaluation. These activities would be linked with efforts to extend the educational outreach of the School through high priority programs for community leaders and mid-career professionals. The third recommendation was to combine the existing action and research facilities of the two Departments — the Community Projects Laboratory of the Department of Architecture and the Laboratory for Environmental Studies of the Department of Urban Studies and Planning — in a new Center tentatively titled the Center for the Human Environment. The proposed Center would encourage experiments in curriculum development as well as other innovative educational efforts. It would also be the home for action-oriented groups working in the field and for teaching-oriented research activities.

Because of budget cuts, the National Science Foundation was not able to fund the proposal under its institutional development program. However, these funding difficulties may be temporary. If not, we intend to disaggregate the proposal and resubmit it under other grant programs. In any case, the NSF Task Force helped members of Architecture and Urban Studies and Planning to reevaluate their efforts and to reach a significant consensus on the future development of the Department and the School.

Several examples of the impact of this reevaluation are worth citing. Based on the NSF Task Force's proposal, a Committee on Non-Degree Programs, coordinated by Mary C. Potter, Professor of Urban Studies and Social Psychology, was set up to examine a wide range of potential programs designed to open up the resources of the Department and the Institute to a range of new groups. Lisa R. Peattie, Professor of Urban Anthropology, chaired a committee responsible for the preparation of guidelines regarding the appropriate scope of field work activities and their relationship to the regular curriculum. Two other committees, one dealing with the Ph.D. program, headed by Professor Kevin A. Lynch, and another dealing with professional degrees, headed by Professor John T. Howard, prepared recommendations which led to substantial modification of the advisory and examination procedures for the doctoral and master's degree programs.

NEW PROGRAMS

UNDERGRADUATE DEGREE PROGRAM IN URBAN STUDIES This past year,

the Department initiated a new program leading to a B.S. in Urban Studies. Forty students were enrolled in the program this year, and the enrollment will increase to 60 next year. The main purposes of the program are to provide a general, but systematic, background and to impart some specific skills for students interested in pursuing a course of graduate study in urban planning, engineering, law, or the social sciences. The program also serves many undergraduates who want to explore a variety of social change strategies in the context of field work, independent research, or community service.

Students are required to take two new subjects designed especially for the undergraduate program. The Junior Year Policy Colloquium, "Perspectives on Urban Issues," explores various analytical and normative perspectives on urban problems and helps each student develop a perspective of his own. Professor Martin Rein taught the seminar this year and chose to focus on the role of governmental task forces in the formulation of public policy. The Senior Year Colloquium, "Urban-Problems in American Society: Responses and Strategies," is intended to help the student draw together his experiences in the program through the study of national programs aimed at controlling or influencing the pattern of urban development and at ameliorating urban social problems. This year the senior colloquium was taught by Visiting Professor Stephen Cohen, who emphasized a comparative approach to the analysis of planning strategies in various countries.

The undergraduate program has a number of special features. An advisory system has been set up to encourage student initiative, while it insures that each student develops a coherent program and receives guidance in carrying through his or her independent work. In the future the Department will experiment with a tutorial format which will provide every undergraduate with an opportunity to work with at least one member of the faculty or staff. Students are also encouraged to engage in a variety of field work and group research projects. Through the Undergraduate Research Opportunities Program, the Department set up a student-run mini-foundation to fund undergraduate research projects. Next year several year-long internships in a city government may be arranged for students who desire such an experience.

An interdepartmental Undergraduate Advisory Committee, chaired by Professor Ralph A. Gakenheimer, Director of the Undergraduate Program, is monitoring the program as it evolves.

COMMUNITY FELLOWS PROGRAM The Department has established the Whitney Young Community Fellows Program to help minority leaders cope with the social and economic development of their communities.

Developed by Melvin King of the New Urban League and by Professor Rodwin, the main aim of the program is to enable a selected group of local leaders to spend the equivalent of an academic year at M.I.T. working with faculty on projects of special importance to the Fellows and their organizations or communities.

Community Fellows will be drawn from the staffs and departments of newly-elected black mayors, minority community development corporations, model cities and poverty program staffs, private minority organizations with action and development components, legal assistance and information offices, and other minority enterprises. A third to a half of the Fellows are expected to come from the Boston region. At a later date, efforts will be made to implement some of the local projects via a local development corporation. Frank S. Jones, Ford Professor in the Department of Civil Engineering, has accepted a two-year appointment in the Department of Urban Studies and Planning (one-third time) and will direct the program. Melvin King, formerly Director of the New Urban League of Greater Boston, will serve as Associate Director and Lecturer in the Department. He will have special responsibility for liaison with the local minority communities and with the Visiting Committee representing key minority and other interested figures. An interdepartmental policy committee chaired by Professor Rodwin will develop general guidelines for the program.

The program is funded through a generous grant from the Rockefeller Foundation, as well as through M.I.T. funds. Formal operations will begin in the fall. Only five or six Fellows had been expected in the first year because the program was not approved nor were funds obtained until April. However, the high quality of the applicants makes it likely that the program will have at least eight to ten Fellows and that still others might be accommodated if additional funds could be raised.

JANUARY INDEPENDENT ACTIVITIES PROGRAM Under the direction of Mr. Lawrence E. Susskind, the Department offered a series of intensive two-week seminars entitled "The Nuts and Bolts of Urban Planning." Topics included housing programs and policies, air photo interpretation, grantsmanship, municipal finance and taxation, zoning law and administration, DISCOURSE, PPBS and data management, urban dynamics, and an introduction to systems analysis.

Over 400 students (including almost two-thirds of all the undergraduate and graduate students in the Department) participated in these seminars. Grants from the Dean of the School of Architecture and Planning and the Student Steering Committee enabled the Department to invite more than 40 speakers and lecturers, including many nationally-

known practitioners and professionals. The general reaction was extremely favorable, and it is hoped that a similar program can be offered again next year.

STUDENTS

The number of master's candidates has increased by 80 per cent over the past five years; there are now 40 men and 20 women enrolled in the program. In that same five-year period, the number of doctoral candidates increased from 15 to 38. This fall the Department initiated a new undergraduate degree program in Urban Studies that will, in a year or two, enroll more than 100 students. Extensive minority recruitment efforts have increased minority student enrollment in the graduate program more than threefold, from 7 in 1970-71 to 24 in 1971-72.

Students have played an effective role in Departmental decision making, serving on all Departmental task forces. In addition, four students serve regularly on the Departmental Policy Committee which meets weekly to consider a wide range of issues. The Policy Committee meetings are open to the entire student body, and student attendance has ranged from 4 to over 15 depending upon the topics under discussion. Students have also participated actively in curriculum development and faculty recruitment decisions.

The admissions process was modified this year to allow 13 graduate students to help interview and evaluate all applicants. In addition, several students were selected to serve as administrative assistants, thereby increasing the involvement of students not only in the formulation of Departmental policy, but also in the day-to-day operations of the undergraduate, graduate, and special programs.

FACULTY AND CURRICULUM DEVELOPMENT

Additions to the faculty this past year included Martin Rein, Professor of Social Policy; Tunney Lee, Associate Professor of Urban Design; John Harris, Associate Professor of Urban Economics and Associate Director of the SPURS Program; Lester Houston, Lecturer; Stephen Cohen, Visiting Professor; Thomas Farer, Visiting Professor of Law; and Jack Wofford, Visiting Lecturer. Herbert J. Gans, Professor of Urban Sociology and Planning, is leaving next year to accept a position at Columbia University. New appointments have been made for next year and new subjects have been added in the following areas.

CITY DESIGN Led by Professor Kevin A. Lynch in the Department of Urban Studies and Planning and by Professor John R. Myer in the Department of Architecture, the city design group has forged a closer

alliance with the urban designers in the Department of Architecture. Project-focused studies continue to provide students with an opportunity to develop skills in city design and to apply them under actual resource and decision-making constraints. Professor Tunney Lee offered two problem-focused studies based on his work with the Cambridge Model Cities Program. Next year Professor Lee will be reorganizing classes in site planning and representation. This past year Philip B. Herr and several associates developed a seminar/studio around their work in Cambridgeport, involving new techniques of determining local environmental and other developmental preferences of teenage, elderly, and other groups whose views in the past have been neglected. New appointments in the city design area will strengthen curriculum offerings in environmental programming, computer-aided design, and environmental policy.

COMPUTER SYSTEMS AND ANALYTICAL METHODS Professor Ronald A. Walter supervised a new Undergraduate Urban Studies Laboratory this past year. Next year, together with Joseph Ferreira, Assistant Professor of Operations Research and Urban Studies, he will offer a graduate laboratory designed to introduce incoming graduate students to mathematical, statistical, and computing fundamentals. Charles Libby, Research Associate, and Wren M. McMains, Lecturer, have helped to establish a new Office of Computing Services within the School of Architecture and Planning. Special short-term seminars, tutorial arrangements, and personalized instruction dealing with computer programming, the design and implementation of new computing systems, data precessing, and the identification of information resources will be available through the new office. Professor William Porter has continued to set new applications of the DISCOURSE language, which is especially suited to environmental analysis. His class dealing with the analysis of urban design and his research on computer-aided design link the analytical methods group and the city design group. Further curriculum development efforts in this area will center around additional laboratory work in computer modeling, possibly supported through the Department's ties with the Cambridge Project, the refinement of a sequence of subjects in public policy analysis and a series of classes on public service systems analysis. Professor Aaron Fleisher, although nominally on sabbatical leave, is playing a major leadership role in organizing these activities.

HOUSING, COMMUNITY DEVELOPMENT, AND URBAN ECONOMICS The housing group in the Department emerged this year as a strong interest group. Professors Bernard J. Frieden, Langley Keyes, and Lisa R. Peattie have helped the Department to reorganize its offerings in this

area. Professors Frank S. Jones of Civil Engineering and Melvin King will add a new dimension to the Department's work in community development. They will jointly teach a full-year seminar dealing with issues and strategies in community development, with emphasis on the social and economic development problems in inner city communities. Their work will augment the efforts of Mr. Justin Gray and Professor Peattie to develop field-work and internship opportunities for students interested in the application of community development strategies. This past year, Mr. Gray set up a variety of field-work projects involving more than 50 students in various field settings. John Harris, Professor of Economics, besides teaching an undergraduate seminar on city structure and economic development, links the Department of Urban Studies and Planning closely with the Department of Economics. The number of students entering the joint Economics-Planning Ph.D. program is increasing, and the number of undergraduates taking work in both Departments is substantial. Additional course work in public finance, taxation, economic modeling, and public expenditure analysis are needed and will probably be developed jointly by the two Departments.

DEVELOPING AREAS The Special Program in Urban and Regional studies (SPURS), now going into its fifth year, continues to bring Fellows from many countries to M.I.T. for a year of intensive study. Most of these Fellows have considerable experience in high level decision making and planning positions in their own countries, and they have provided an additional teaching resource in the area of developing countries. This past year an informal SPURS seminar was initiated which culminated in a Colloquium on National Urban Growth Strategies. Next year, the SPURS seminar will become a formal part of the curriculum.

This spring a group from the Ford Foundation reviewed the SPURS Program as well as other international activities at M.I.T. M.I.T. is receiving visitors from all parts of the world, for SPURS is the only program of its kind in this country, with few competitors even abroad. The program received an extension of its grant for another year, pending the decision of a Ford Committee set up to evaluate the need for further Foundation efforts in developing countries. If the Foundation decides to place a high priority on work in the field of developing countries, we believe SPURS can expect support in the future.

URBAN SERVICES AND INSTITUTIONAL CHANGE With the addition to the Department of Martin Rein, Professor of Social Policy, student interest in the area of urban services and social policy has grown. Special seminars are currently being offered in the areas of educational

planning, health planning, welfare policy, social program development and evaluation, poverty law, and strategies for institutional change. These activities build on the efforts made this past year by Professors Walter and Peattie, and Instructors Leonard and Suzann Buckle to sharpen various research and field methods for testing hypotheses about social groups, organizations, and community change. Robert Fogelson, Professor of Urban History and Planning, taught a joint seminar this year with the Harvard Law School, "Institutional Change in Urban America," which focused on the court system in the United States. Next year Professors Fogelson and Rein will again offer a seminar with the Harvard Law School, shifting their focus to the welfare system and the formulation of welfare policy in the United States. This past year Visiting Professor Thomas Farer offered a seminar on poverty law and Visiting Lecturer Jack Wofford led a seminar on legal issues in transportation planning.

RESEARCH

Besides continuing work on computing systems and computer-aided design, the Department is actively engaged in several new research enterprises.

The Department received a grant from the Urban Systems Laboratory to examine the feasibility of alternative development strategies for the Boston region and to formulate a research prospectus in order to obtain outside financing for this project. Emphasis is on the factors over which public policy might exert leverage in shaping urban development. Key examples are land use controls, public investment in capital improvements, and the design of transportation and other social service systems. Also to be considered are ways in which Federal and state revenue sharing and taxing arrangements might affect the availability of housing, educational opportunities, and the financing of development programs at the local and regional levels.

A team of students and faculty from the Department of Urban Studies and Planning and other M.I.T. departments, such as Economics, Political Science, and Civil Engineering, is being assembled to initiate preliminary inventory studies for this project and to develop effective collaborative mechinisms, including interdisciplinary seminars involving key public officials at the regional, state and local level. This activity is under the direction of Professor Rodwin and Lawrence Susskind. The Department will also tie the Boston Regional Development study to exploratory analyses of urban growth strategies for the United States. Mr. Susskind's policy seminar this year, "New Communities and National Urban Growth Policies," provided a start in this direction.

There are two research efforts underway in the city design area: studies of various techniques that designers actually use in thinking about and solving problems, and studies of the ways in which individuals learn about cities and the role which city settings, in turn, play as "educative environments."

Recent studies of how designers work have led to the further refinement of DISCOURSE, a computer language suited to the consideration of environmental design questions. Professor William Porter and his colleagues in both Planning and Architecture have been working to develop more effective ways of using computer languages to describe and manipulate information on urban activity systems, processes of urban development, and the linkages between environmental factors and decision variables. Projects involving DISCOURSE have included a study of best route locations for a highway in an urban area and studies of the logical sequencing of development in new towns relative to various strategies for constructing community facilities.

The "City Signs and Lights Projects," completed this past year under the direction of Steven Carr, experimented with new systems of signs for motorists and pedestrians, systems of lighting, and the use of an information center as a way of improving the users' understanding of the city. Under the direction of Professor Lynch and Mr. Michael Southworth, several other projects aimed at increasing the educative potential of the city were also initiated this year. These include an urban travel program for young people which creates learning opportunities in the public transit environment, investigations of innovative educational possibilities for new communities that draw on the process of community building itself, and a program for the Lowell Massachusetts Model Cities Agency to develop the canals and mills of Lowell as learning settings.

OTHER ACTIVITIES

A Departmental newsletter, edited by Mr. Susskind and published in conjunction with the M.I.T. Alumni Association, brought alumni up-to-date on various aspects of the Departmental program. The Annual Alumni Fund Drive headed by Professor Rodwin and Alan Rabinowitz (Ph.D., '69) was the most successful in many years.

Special efforts were made to link the activities of the Department to work being carried out in other programs at the Institute. Professor Frieden and Mr. Susskind helped to formulate a joint Harvard-M.I.T. research proposal on Health Sciences and Technology, which involves a study of the current need for programs of manpower development in health planning. Professor Rodwin served on the Urban Systems

Laboratory Steering Committee, the Simplex Committee headed by Dr. Benson Snyder, the Ad Hoc Committee on the Organization of International Interdisciplinary Policy Research, the C.F.P. Advisory Committee, and the policy committee for the School of Architecture and Planning. As of July 1, 1971, Professor Frieden has been appointed Director of the Harvard-M.I.T. Center for Urban Studies. Professor Peattie was appointed as a member of the Committee on Educational Policy, and Professor Porter continues to serve as a member of C.J.A.C. Professor Fleisher is a member of the steering committee for the Cambridge Project; Professor Potter serves on Dr. Holloman's Ad Hoc Committee on Non-Degree Special Study Programs at M.I.T.; Justin Gray is on the Advisory Committee of M.I.T.'s Urban Action Program; and Professor Howard continues as a member of the Graduate School Policy Committee.

FUTURE NEEDS AND PROSPECTS

The Department has tapped additional resources in order to expand its research efforts, augment its staff, and help support its students. Although we have increased the number of minority faculty members in the Department, more must be done. Fortunately, the growing number of black students makes this prospect more than a pious aspiration. However, there is also a need to broaden the range of students who are admitted from Puerto Rican, American Indian, Mexican-American, and Oriental communities.

In the year ahead the Department plans to reorganize some of its subject offerings. Given the bleak financial prospects that face university administrators today, the Department of Urban Studies must be concerned with effective ways of evaluating the costs and benefits of diverse activities, and of assuring students and the M.I.T. Administration that we are effectively reducing outlays while enhancing the quality of performance.

POSTSCRIPT

Two respected members of the School have retired. Frederick J. Adams served as the first Chairman of the Department from 1944 to 1956. An Emeritus Professor since 1965, he retired at the end of June 1971 and will live in England. A large proportion of the active practitioners today in high offices in the field of planning have earned their spurs under his guidance. The love and affection they bear for him is a testimony to the extraordinary personal qualities of a man who served his family, the Institute, and the profession with remarkable courage, warmth, and dignity.

Dean Lawrence B. Anderson is also retiring. He, too, has served the School and the Department with exceptional grace and wisdom, especially during the past two or three years when a heart ailment would have led others to a drastic lessening of activity or to retirement. His steady and imperturbable leadership has sustained the School in difficult periods. M.I.T. is fortunate indeed that he will return before too long to inspire young scholars again.

LLOYD RODWIN

SCHOOL OF ENGINEERING

The past year saw the profession of engineering, and schools of engineering, subjected to severe criticism and searching doubt. With unemployment among engineers in the range from 5 per cent to 10 per cent of the work force, and in the face of projections of continuing underemployment, it was inevitable that criticism and examination would come from within the ranks of the profession as well as from elsewhere in the society. The viewpoints expressed have covered the full range from a reassertion of the primacy of traditional technological efforts and priorities, to the curious view that all of modern society's problems are the result of an excess of technological activity, which should be greatly reduced, if not eliminated.

Throughout the plethora of rhetorical breast-beating, honest reappraisal, and searching for new directions, two observations seem pertinent: 1. Modern society is utterly dependent upon technological activity; without technology it would be impossible to feed, house, transport, or otherwise sustain a population at anything like the density and material standards of living that are characteristic of the United States. It is naive to an extreme to suggest that this society should now turn away from technological enterprise. While it is indeed true that technological activity, and the rate of societal change it has engendered, have produced major problems for our society, these problems are nothing compared with those that would arise were we now to turn our backs on technology. 2. Technological activity has frequently followed priorities and directions that have not been sufficiently sensitive to the full spectrum of the complex interaction among technological developments, human needs and

capabilities, and socioeconomic institutions. The decline of urban rapid transit systems and the accompanying chaos of commutation by private automobile constitute a familiar and fundamental example of the shortsightedness that can grow out of technological innovation. What is needed is a concerted effort on the part of both engineers and those whose needs they serve to delineate, explore, and understand the consequences of technologically-induced change, and to foster wise and timely choice among fully-developed alternatives.

The national concerns about the nature and direction of technological enterprise, and thus of engineering practice and engineering education, have, of course, had an impact on the School of Engineering at M.I.T. Both the students and the faculty of the School have manifested these concerns, through the nature of educational programs offered by the school and through subtle shifts in enrollment patterns.

There has been a continuation of the growth of programs of engineering research and education in problem areas that are strongly coupled to social needs and human issues. For example:

1. A research program in energy systems, with emphasis on the dynamics of supply and demand and on the factors that shape alternatives in the long-range planning for a national energy policy is emerging. Although this program has a base within the School, involving faculty members from nearly every engineering department and growing out of an effort in the Electric Power Systems Engineering Laboratory, it has engaged faculty and graduate students from the Department of Economics, from the Department of Political Science, and from the Sloan School of Management as well.
2. During the year a school-wide Committee on Biomedical Engineering acted to create a new graduate program in biomedical engineering. The program, which involves faculty and students from every department in the School, is a measure of the rapid growth in recent years of interest in applying engineering methods and techniques to problems associated with living systems. These efforts cover a very wide spectrum, from biomaterials and the engineering design of prosthetic devices and systems, through the application of engineering principles to the treatment of disease, to the use of information processing techniques in diagnosis and in the analysis of biologically-generated signals. There is, of course, essential interaction in this program with life scientists, and with physicians in essentially every teaching hospital in greater Boston.
3. Three departments — Ocean Engineering, Aeronautics and Astronautics, and Civil Engineering — are jointly developing a research program in transportation systems. This effort is taking a broad view of the social and economic basis for transportation requirements, with the

objective of exploring the ways in which different forms of transportation interact and compete in the satisfaction of a variety of needs.

4. Efforts in several departments are aimed at those aspects of environmental quality that relate to the generation, dispersion, disposal, and recycling of wastes. These programs range from studies of the chemical kinetics of combustion and pollutant formation, to the fluid mechanics that govern the dispersion of pollutants in the air and in water, to the sensing problems associated with the sorting of solid wastes.

These emerging and growing efforts within the School have several features in common. First, they build on strong existing competences in engineering science and in high technology. Second, they are multidisciplinary in nature, requiring the participation of persons skilled in widely differing specialties, many of which have not traditionally fallen within the scope of engineering. Third, they require the development of new modes of interaction among the participants; progress depends crucially upon the development of meaningful and effective collaboration among several persons in proposal writing, in goal setting, and in sharing findings and conclusions.

These developments, which represent a return to original goals in the creative application of scientific principles to social needs, and which build upon a highly developed base of engineering science, are entirely appropriate to the School of Engineering at M.I.T. in the 1970's. They capitalize on the unique capabilities of the School, with its wide range of activities, and its traditional strength in engineering science, and they reflect the growing concern, shared by students and faculty, for engagement with problems that are clearly important for this society at this point in its history.

CENTER FOR ADVANCED ENGINEERING STUDY

The Center continued its two-pronged effort aimed at continuing education for engineers. In one area of effort, the development of videotapes, films, study guides, and textbooks for self-study subjects has continued. Several subjects, including ones in calculus and probability, are now being marketed and have found wide acceptance, particularly with industrial concerns that are seeking ways to provide opportunities for educational renewal for staff members. The development of new subjects is continuing, with effort during much of the year focused on a self-study subject in surface and colloid chemistry.

A second area of effort is that of residential programs. The Practicing Engineer Advanced Study Program and the Systematic Policy Analysis Program were offered once again as essentially full-time activities for engineers and other professionals in mid-career.

In December, 1970, Professor Harold S. Mickley resigned as Director of the Center for Advanced Engineering Studies, and took a leave of absence from the Institute to engage in industrial research. Professor Mickley had served as Director of C.A.E.S. since its formation in 1965. He was largely responsible for the high standards set by the Center in both its self-study and residential programs.

ENROLLMENT TRENDS

During the 1960's undergraduate engineering enrollments in the United States were essentially static in spite of the fact that undergraduate student enrollments nearly doubled during the decade. Graduate enrollments, which grew rapidly during the first half of the decade, stabilized and began to decline during the closing years of the decade. The widespread, and widely publicized, unemployment that has affected the engineering profession for the past two years has had a major effect on engineering enrollments nationally. Although the lag associated with the four to eight year period of formal education is such that there has not yet occurred any drop in the rates at which degrees are awarded, the rates at which young people are entering both undergraduate and graduate study in engineering are sharply off. The resulting drop in output will appear in a year or two. If fragmentary information, largely word-of-mouth in nature, concerning undergraduate enrollments at the major schools of engineering is correct, the society may already be headed toward a new shortage of engineering manpower, a shortage which would first be felt in 1974 or 1975.

At M.I.T. enrollments in the School of Engineering continued the very slight downward trend that began four years ago. Changes for each department, and for the School as a whole are shown in the following table.

M.I.T. Engineering Enrollments

	Undergraduate			Graduate		
Department	1969-70	1970-71	Change	1969-70	1970-71	Change
Civil	94	99	+5	182	192	+10
Mechanical	160	154	−6	229	228	−1
Metallurgy and Materials Science	53	47	−6	139	140	+1
Electrical	649	663	+14	443	416	−27
Chemical	87	92	+5	121	146	+25
Ocean	16	15	−1	129	122	−7
Aeronautics and Astronautics	172	123	−49	184	177	−7
Nuclear	0	0	—	128	112	−6
Total	1231	1193	−38 (−3.1%)	1555	1533	−22 (−1.4%)

During the year 1970-1971, the School awarded the following degrees:

	Sept. '70	Feb. '71	June '71
Bachelor of Science	45	50	292
Master of Science	121	95	205
Engineer	16	25	72
Ph.D. or Sc.D.	39	66	70
Total	221	236	639

On the basis of credit units, subjects taught in the School of Engineering accounted for approximately 31 per cent of the teaching at the Institute.

PERSONNEL HIGHLIGHTS

In August, 1970, Dr. Raymond L. Bisplinghoff announced his resignation as Dean of the School of Engineering. Dr. Bisplinghoff, who had served as Dean since 1968, took leave of absence from the Institute to serve as Deputy Head of the National Science Foundation.

In December, 1970, Dr. Paul E. Gray, Class of 1922 Professor of Electrical Engineering, was appointed to succeed Dr. Bisplinghoff as Dean. Dean Gray's tenure was to last for just seven months as a result of his election by the Corporation to the position of Chancellor, effective July 1, 1971.

In June the appointment of Dr. Alfred A. H. Keil as Dean of the School of Engineering, effective July 1, 1971, was announced. Dr. Keil, who has served as Head of the Department of Naval Architecture and Marine Engineering (now the Department of Ocean Engineering) since 1966, brings to the School an exceptional record of accomplishment in engineering management and education.

At the same time, the appointment of Professor James D. Bruce, Executive Officer of the Department of Electrical Engineering, as Associate Dean of the School of Engineering was announced. Dr. Bruce has recently been concerned with the development of computer-based management information systems, which are likely to be of interest to the School.

Personnel highlights within the specific departments of the School of Engineering are included in the following departmental reports.

OTHER MATTERS

In recognition of the broadening scope of activities in the Department of Naval Architecture and Marine Engineering, the name of the Department was changed late in the year to the Department of Ocean Engineering.

The Department of Ocean Engineering will offer both undergraduate and graduate degrees in Ocean Engineering as well as in Naval Architecture and Marine Engineering and will operate the Pratt School of Naval Architecture and Marine Engineering as an integral part of the Department.

In October the Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics was dedicated in conjuction with a symposium concerning "The Water Environment and Human Needs." The new laboratory has doubled the floor space of the original Hydrodynamics Laboratory and provides additional space for light experimentation as well as new classrooms, computer facilities, a water quality laboratory, a reading room, and office space.

PAUL E. GRAY

DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS

During the past year teaching and research activity in the Department remained at high level although undergraduate enrollment continued to fall for the seventh consecutive term, reflecting the uncertainty in the aerospace industry. Graduate enrollment, however, decreased only slightly from the record peak of 1969 and 1970. The expected drop in research support did not materialize and in fact support level is projected to increase slightly next year. However, the continuing reduction in available fellowships and hence increased dependence of graduate students on contract support is a matter of continuing concern.

The success of the Department in maintaining the high level of research activity which forms the basic fabric of our graduate instruction and student support is evidence of the strength of aerospace technology in times of uncertain economic stability. For example, although Department of Defense support of research in the Department has dropped steadily during the past four years from 68 per cent in 1968 to an anticipated 35 per cent in 1972, this reduction has been more than compensated for by an increase in NASA funding for both space and aeronautical projects and the addition of Department of Transportation support from almost nothing in 1968 to 10 per cent in 1971. The high level of technology and product reliability which is characteristic of aerospace engineering finds many applications in other fields as evidenced by the growing departmental activity in bioengineering and in magnetohydrodynamic and fusion power conversion. The Department will always encourage research in areas in which faculty interests and skills can

make a contribution. However, it is expected that the growing interest in near-earth space applications such as communications and earth resources satellites and the rapidly growing field of air transportation with its potentials for relieving short-haul ground congestion will provide more than enough support to maintain a high level of research activity and a growing market for the skills of our graduates.

UNDERGRADUATE EDUCATION

Bachelor's degrees were awarded to a total of 38 students as compared to 55 last year.

With the cooperation of the teaching units, the Undergraduate Committee, under the chairmanship of Professor Eugene E. Covert, reviewed the undergraduate course of study. In 1964 the Department requirements were reduced and the design or systems subject made an elective rather than a requirement. As a consequence some of our students failed to appreciate the full reason for the breadth of our course of study as discussed above. To overcome this problem the Department faculty approved as requirements a systems subject and a structures subject. Although this reduces the unrestricted elective hours from 90 to 78 Course XVI remains one of the more flexible courses of study at M.I.T.

Nine graduates and 13 undergraduates in the Department took part in the Department activities organized for the January Independent Activities Period. The most popular type of offering seemed to be a short course that was faculty, not student, organized. A questionnaire circulated in February indicated that 85 per cent of those responding favored I.A.P.

The Department continued to increase its efforts in the Undergraduate Research Opportunities Program. Four undergraduates were enrolled in the program in the fall term and eight in the spring term.

This year the James Means Memorial Prize was awarded to Julius Brandeis, Michael D. Mathers, and William J. Swedish. The following students received the Admiral Luis de Florez Award: Antonio L. Elias, Roderick A. Hyde, Thomas T. Milkie, and Henry S. Vaccaro. The Henry Webb Salisbury Award (highest cumulative grade point average) was presented to Michael A. Pustejovsky.

In a continuing effort to increase informal social interaction between faculty and students, a Department coffee hour was implemented under Professor Wallace E. Vander Velde's leadership and informal dinners following key seminar speakers provided students with the opportunity for further discussion with the speaker. Particularly successful was an evening arranged with Astronaut Ed Mitchel to which primarily freshmen who had indicated an interest in aeronautics and astronautics were

invited. Another highlight was a steak fry organized by the students on the evening before the departmental Visiting Committee meeting which provided an opportunity for the members of this Committee to meet students and faculty on an informal basis.

GRADUATE EDUCATION

Professor Judson R. Baron continued serving as Chairman of the Graduate Department Committee, Graduate Registration Officer, and member of the Committee on Graduate School Policy. Graduate enrollment decreased slightly to 178 this year from the record peak of 184 in 1969-70.

During the course of the year Professor Harold Y. Wachman chaired the Doctoral Committee, overseeing the admission of 15 students to a formal Doctor's program on the basis of qualifying examinations taken by 25 candidates. This represents an appreciable decrease from the previous year's 39 with 28 qualifying.

The Interdepartmental Doctoral Program in Instrumentation under Professor Walter Wrigley's chairmanship continued with satisfactory vigor. A total of 19 students participated, two less than the previous year.

Professor H. Philip Whitaker continued as Chairman of the Engineering Degree Program which is attracting increased interest among the student body with eight continuing in the program as opposed to three in the previous year. An innovation this year was a highly successful six-unit seminar conducted by Mr. Joseph Yamron, formerly Vice President of Sanders Associates, Inc., on the topic, "A Management View of Engineering," which was recommended for the engineer program. The engineering environment in high technology aerospace companies was examined with the view of exposing the student to the realistic factors which companies have to consider so that he would be better prepared to understand the decision process that will affect his future career in engineering.

Eight new graduate subjects were initiated during the year as Advanced Special Subjects (16.601). Six and possibly seven are expected to be offered again with regularly assigned subject numbers.

The Department has continued to assess the relevance of the teaching program to our graduates and this year circularized all those students who were on the 1968 degree lists since these represented a body of recent graduates with some experience in the use of their education. One hundred and twenty-nine questionnaires were sent out and some 22 replies were received, a small sample. The results indicated that 70 per cent to 80 per cent felt the instruction, course content, applicability, and

usefulness as background material was good to excellent, the remainder generally listing these as adequate.

FACULTY ACTIVITIES

Promotions of faculty members included Assistant Professors Louis L. Bucciarelli, John J. Deyst, James P. Moran, and Pin Tong to Associate Professor and Associate Professor Robert E. Simpson to Professor.

Professor Raymond L. Bisplinghoff was on leave of absence from the Department to serve as Deputy Director of the National Science Foundation. Professor James W. Mar was absent to serve as Chief Scientist of the Air Force. Professors Norman D. Ham and John Dugundji were on sabbatical. Professor Joseph Bicknell continued on leave.

Professor Robert L. Halfman served as Associate Chairman of the Faculty, as well as serving on some fourteen Institute committees and continuing his work on the Experimental Study Group. Professor Sheila E. Widnall continued to serve on the M.I.T. Commission and on the Rogers Task Force on Education while maintaining her high level of research activity in the Department.

Professors Oliver and Bucciarelli developed a new concept in undergraduate education, the Concourse Experiment, an integrated program in engineering science and humanities for the first two years at M.I.T., which was approved for the coming year.

Professor Yao T. Li continued as Chairman of the Department's general seminars, organizing a distinguished panel of some 28 speakers.

Professor Alfred J. Eggers continued as Hunsaker Professor this year on a part-time basis and was responsible for organizing a most interesting Working Group on Philosophy, Science and Technology. This group met on May 7th and 8th and established the framework for what will undoubtedly be a continuing dialogue between philosophers, scientists, and engineers.

A high-light of Department activities this year was the Lester Gardner Lecture by Sir Geoffrey I. Taylor who presented a fascinating history of the early days of aviation to an overflow audience.

Professor Jean F. Louis chaired a program at the request of the Department of the Interior on open-cycle coal-fired MHD power generation which included ten faculty members from five Institute departments. The report of this group was very well received and will form the basis of continuing work in this important area.

Professor David B. Stickler served as Coordinator of the Undergraduate Experimental Projects Laboratory.

Finally, Professor Eugene E. Covert supervised a most interesting

undergraduate project centered around the design and construction of a man-powered airplane which will be entered in the continuing competition for the first man-powered flight.

DIVISIONS OF INSTRUCTION AND THE RESEARCH LABORATORIES

The Division of Mechanics and Physics of Fluids continues to attract a high level of graduate interest although the research support in this area is insufficient for all those students who wish to participate in this important area. Research on gas surface interaction has progressed and the techniques developed are now being extended to serve as a tool to study the kinetics of growth of small ice crystals and water droplets in the upper atmosphere. An understanding of this phenomenon and its dependence on heterogeneous nucleation centers will eventually provide a tool in the analysis of the distribution and drift rate of droplets in the stratosphere in the altitude range of 70,000 to 50,000 ft. This should shed light on the little known problems associated with supersonic and hypersonic flight in the upper atmosphere.

Instrumentation, Guidance, and Control continues to attract the largest group of graduate students in the Department. Research support through the Draper Laboratory, Measurement Systems, Man-Vehicle, and Laser Systems Laboratories remains at a sound level. It is hoped that whatever decision is taken as to the Draper Laboratory and its association with M.I.T., that this association will continue to permit continuation of the close interaction between the teaching and research activity of the Department and the Laboratory. At the present time 40 per cent of the students in this Division are supported by the Draper Laboratory. Of particular importance to the Department is the opportunity which this great Laboratory provides to students for close interaction with ongoing engineering systems and for apprenticeship in the solution of real engineering problems.

The Measurement Systems Laboratory has continued active programs on planetary gravitational fields and the determination of the Newtonian gravitational constant, on space dynamics and optimal control theory in support of the Mariner and planetary Explorer program, and on terrestrial navigation with particular emphasis on the potential of aircraft inertial navigation systems to assist in the overall air traffic control problem. The Man-Vehicle Laboratory continued studies of human dynamics space orientation, of life support in unusual environments, of the biophysical characteristics of the vestibular system, on display research for air traffic control and in biomedical sciences, developing posture platform tests for clinical diagnosis, methods of measuring scleral stretching for the diagnosis of glaucoma and conducting research in

biomathematics to develop basis theories in learning and problem solving. The relatively new Laser Systems Laboratory was active in developing new techniques for the measurement of dynamic behavior of structures and in the measurement of low- and high-speed flows as well as participating with the Man-Vehicle Laboratory in the measurement of scleral stretching in vivo.

The Division of Propulsion and Power has the responsibility for teaching and research in a broad range of subjects included in and related to the general topic of energy conversion. Subjects offered include chemical rocket propulsion, aircraft gas turbine propulsion, nuclear rockets, ionized gases and plasma propulsion, and plasma kinetic theory relevant to fusion power and solar plasma. Currently, there is some shift in emphasis towards such problems as aircraft noise and pollution which has maintained the overall level of research despite some decrease in the number of students interested in space related research.

The Division's research is carried on within three laboratories, Space Propulsion, Gas Turbine, and Plasma Physics and Space Science. Research in the Space Propulsion Laboratory includes studies of MHD power generation, charged alkali amalgam colloids, pulsed plasma accelerators, liquid colloid nuclear reactors, and hybrid rockets. Three doctoral programs were completed this year. In the Gas Turbine Laboratory, research includes studies of supersonic jet noise, unsteady and three dimensional flow in transonic compressors, turbomachine noise, and unsteady flow and heat transfer in cooled turbines. Optical visualization and fast time response measurement techniques are being developed in all of these programs. The Laboratory for Plasma Physics and Space Sciences is continuing research on plasma dynamics with special emphasis on linear instabilities in inhomogeneous systems. Its efforts are motivated by applications to fusion power and interplanetary plasmas.

The Aeroelastic and Structures Research Laboratory has carried out research investigations on unsteady aerodynamics and nonlinear elastic stability of helicopter rotors; panel flutter; the development of structural analysis methods by analytical, finite-difference, and finite-element methods for linear, nonlinear, large deflection, elastic, and inelastic behavior, including both static and transient response problems and stress singularities; and composite materials including mechanical properties of metallic composites as well as mechanical properties and methods of analysis of aerospace structural elements composed of advanced fibrous composites. Work has also continued on analyzing and developing concepts for containing and controlling fragments in burst rotors of aircraft turbojet engines and on the persistence of trailing vortices shed from the tips of lifting airfoils.

A special subject was given during the spring term on Fracture, Fatigue, and Design with ten invited speakers from industry and government. During the summer term a short intensive subject was given on finite element methods in solid and continuum mechanics jointly with the Department of Civil Engineering.

Professor Herbert Sander of the Technical University of Berlin has been associated with this Division as a Visiting Associate Professor and has contributed appreciably to both teaching and research activities of the Division.

The year saw a major expansion of the activities in Flight Transportation. Several new projects were initiated in such areas as transportation information, air traffic control, and noise from V/STOL aircraft. New facilities added were the SST cockpit simulator donated by Boeing, the development of an acoustic wind tunnel and the first operation of the computerized data file. The Laboratory has joint programs with Civil Engineering, Ocean Engineering, Urban Systems and Draper Laboratories. Another joint project has involved the Flight Transportation, Electronic Systems, Man-Vehicle, and Lincoln Laboratories in studying the application of cockpit traffic situation display to the terminal area problems of the ATC system. Work is also continuing with the Mechanical Engineering Department to determine the mechanism of noise generation of V/STOL aircraft and the acoustic propagation in urban areas.

The Aerophysics Laboratory has continued research on re-entry vehicle communication blackout; the measurements of the aerodynamic forces on various bodies of revolution using the magnetic suspension system development at the Laboratory; methods of improving the simulation of store jettison tests in the wind tunnel, and the aerodynamic interaction between external stores and aircraft. Both analytical and experimental studies were carried out on real gas problems applicable to hypersonic flows such as the design for minimization of radiant energy transfer from the shock layer to the body surface.

Finally, the Wright Brothers Wind Tunnel has continued to be a useful tool for low-speed aerodynamic research. An active program on wind velocities around buildings, including Westgate I and II at M.I.T. and on the dynamic response of buildings to natural winds has been initiated. The Tunnel has also supported the work on vortex structure and behavior and has provided a facility for undergraduate research on special projects for some 16 students.

R. H. MILLER

DEPARTMENT OF CHEMICAL ENGINEERING

DEPARTMENTAL

The year started with the June, 1970, Endicott House Conference on Future Trends in the Chemical Industries and in Chemical Engineering Education. This two-week meeting, in which the entire staff plus three students participated, was the culmination of preparatory studies made over the entire previous year. Agreement was reached in the meeting on education goals, and teaching methods were reviewed. Curriculum revision and development, both undergraduate and graduate, were extensively planned, with new areas carefully defined. The relative importance of the Practice School was reaffirmed. More formal arrangements for joint study of management and chemical engineering were recommended. Student relations were explored, and the desirability of an extended advisor system for the graduates was recognized.

A healthy future was anticipated for the chemical and allied industries, which will provide increasing opportunities for suitably trained chemical engineers. A renewed interest in our program may be reflected in the 40 sophomores and 60 new graduate students in the Department this year, both up about 50 per cent from last year. Our strength has always been derived in large part from our emphasis on applied chemistry, and we plan to continue this. Environmental engineering, enzyme technology, surface and colloid chemistry, polymers, and biomedical engineering, all activities within the Department, need further attention.

Chemical engineering was originally established as a course of instruction at M.I.T. in 1888, the first in the world. A separate Department, with Warren K. Lewis as Head, was created in 1921. A convocation to mark the 50th anniversary of this event was held on October 23 and 24. Of the 181 alumni attending, there were 22 company presidents, 29 vice presidents, and eight directors of research, reflecting the Department's remarkable record of educating top executives. Both the social and technical events were favorably received by alumni of the Department, who recommended that another convocation be held before the year 2021.

Our staff members continue their heavy involvement in critical problems of the Institute, the profession, and the nation. Professor R. F. Baddour chaired an Environmental Quality Task Force last summer which recommended the establishment of an Environmental Laboratory at M.I.T., and this was done last fall, with Professor Baddour as Director. The laboratory is interdisciplinary and is designed to contract mission oriented programs related to environmental problems. Several

of our faculty members are active on the committees of the National Academy of Engineering and National Research Council: Professor G. C. Williams, serving on Automotive Pollution; Professor H. C. Hottel, on Coal Combustion; and Professor C. N. Satterfield, on Nitrogen Oxide Emissions. Professor H. P. Meissner, recently appointed Lamont duPont Professor of Chemical Engineering, has become the Department's first Executive Officer. Professor E. R. Gilliland was elected a Fellow of the American Institute of Chemical Engineers and received the Founders Award of the A.I.Ch.E. Professor R. C. Reid was given the Distinguished Engineering Alumni Award at Purdue for this year, and has accepted a five-year appointment as editor of the *AIChE Journal*. Professor E. W. Merrill has been appointed Visiting Research Associate in Surgery at the Children's Hospital in Boston.

EDUCATION

The implementation of the Endicott conference recommendations was begun in the fall term. Development continues on the two new undergraduate subjects dealing with combustion-related pollution problems. Professor G. Margolis is reorganizing the undergraduate Chemical Engineering Laboratory so that our students will work on a sufficiently broad set of problems to provide them with reasonable laboratory skills. Professor L. B. Evans organized and carried forward a large integrated laboratory project on the enzyme-catalyzed isomerization of glucose to fructose. This successful interdisciplinary effort involved participation of staff members from Nutrition and Food Science, notably Professors D. I. C. Wang and C. L. Cooney. Another new laboratory subject involving chemical engineers is the Interdisciplinary Environmental Laboratory, in which Professors A. F. Sarofim and M. Modell worked with members of several other Departments.

Professor P. L. T. Brian is continuing to develop a subject on "Staged Processes," whereby sophomores and freshmen are introduced to this concept using various problems of professional significance. Simultaneously, the students learn the use of the computer. In Professor Evans' seminar on Technology Assessment, implications of new developments in industrial chemistry on society were explored.

In the January Independent Activities Period, staff members were involved broadly in this Institute-wide experiment in education. Various types of subjects and seminars were offered, ranging from an interdisciplinary enzyme laboratory project involving Professors Cooney, Meissner, and Wang, to a study involving Professors Sarofim and Fleming of the new SO_2 removal system destined for the Boston Edison Company power plants. Professor K. A. Smith conducted a seminar in Hydrodynamic

Instability, Professor Evans held one on Dynamic Programming, and Professor R. S. Virk, one on Turbulence. A computer seminar for underclassmen was particularly successful.

RESEARCH

The Department's research activities continue over a broad front. In the biomedical field, Professor Merrill's development of lecithin aerosols for alleviating pulmonary distress, especially in newborn infants, is highly promising and is undergoing extensive animal testing. Advances continue to be made in developing polymeric material suitable for implantation in the body. The Department is participating in the development of a major interdisciplinary program on enzyme technology in cooperation with the Departments of Chemistry, Nutrition and Food Science, and Biology. There are several active projects in the environmental area: Professor Margolis, Professor Meissner, and Professor Modell are studying SO_2 removal from stack gases and subsequent conversion to sulfur by the Wackenroder reaction; Professor J. B. Howard is studying SO_2 removal with solid lime; Professor J. E. Vivian is exploring SO_2 removal by scrubbing with an aqueous lime slurry; Professors Williams and Satterfield are working on methods of reducing nitrogen oxide emissions; Professors Hottel and Howard are involved in a study of problems associated with meeting our national energy requirements. Problems in fuel utilization and combustion, as well as the combustion of solid wastes, are being studied in the Department's Fuels Research Laboratory under Professors Hottel, Williams, Sarofim, and Howard. Electrochemistry is an active area involving Professor Gilliland's work on secondary battery problems and Professor Meissner's studies of rate-limiting steps in electrochemical reduction of organic materials. Mechanisms of catalysis and associated problems of mass transfer are being explored in their various aspects by Professors Baddour, Modell, and Satterfield. Rates of sublimation and of crystallization are being studied by Professors Reid and Margolis, while research on various aspects of heat and mass transfer continues under the direction of Professors Smith, Vivian, Brian, and Virk. Professor Meissner has developed useful methods for activity coefficient predictions for electrolytes in aqueous solutions. Professor Evans has further explored the use of the computer in control and optimization of chemical processes.

The projects briefly cited here are only examples of the extensive research underway in the Department, which ranges from water desalination to polymer studies, from blood rheology to new processes for recovery of nickel from ores.

HERMAN P. MEISSNER

DEPARTMENT OF CIVIL ENGINEERING

This year has seen an amplification and further implementation of the new directions adopted by the Department over the last several years. These initiatives involve a broadening of our approach to civil engineering from a former primary concern with analysis and with the response of physical systems to include the whole interdisciplinary process by which constructed facilities are realized. The common ingredient in this broadening is our increasing attention to the general framework of problem formulation. This involves the consideration of various quality-of-life objectives in addition to the usual objective of economic efficiency. It incorporates social and political constraints in addition to the technical ones, and it recognizes explicitly the role of chance. It includes a search for alternative solutions, and finally, it involves the affected community in the process of choice among these alternatives.

In implementing these new ideas we continue to follow the effective path which begins with sponsored research. In this way, research results feed the educational program beginning first at the graduate level and working into the undergraduate curriculum as the material becomes distilled and acquires organization. The year's activities are highlighted below in this same order concentrating upon those items which reflect the broadened outlook.

RESEARCH

Professors Perkins, Schaake, Marks, Major, and Harley have received a major grant from the Argentine government for the development, evaluation, and implementation of a system of economic and engineering mathematical models for river basin planning. This effort has three objectives:

1. The creation of a modern planning framework around which future river basin planning in Argentina can be structured;
2. The creation of a nucleus of Argentine professionals who are trained in both the theory and application of modern river basin planning methods; and
3. The creation of a comprehensive development program for the basin of the Rio Colorado based upon the application of these modern methods and taking into account the balance of pertinent physical, economic, political, and social factors important to Argentina. This project is providing us with the opportunity of integrating, into a coherent and useful package, the recent research advances of our faculty and others while providing both students and faculty some first-hand experience with multidisciplinary research.

In the structural area we have begun, under the leadership of Professor Hansen, a many-faceted study in the area of building systems with the support of the NSF. Included will be: advanced computer-based building design, especially the problems of storing and retrieving the data necessary for the integration of various aspects of design; development of improved models for quantitative evaluation of alternative designs including such cost elements as construction time and maintenance; performance-based specifications; and an analysis of the interaction between the economy and the building industry.

A second major study in this area will apply past research in earthquake engineering to the long-ignored problem of realistic seismic protection for East Coast cities. This study is also sponsored by the NSF and is supervised by Professor Whitman.

Professors Manheim and Pecknold with Messrs. Suhrbier and Ruiter have moved into a new phase of their work concerned with community and environmental factors in transportation planning which is being done for the Highway Research Board. Having developed a series of location and design procedures which take account of the incidence and magnitude of the impacts of project alternatives upon various community interest groups, the team is now testing these methods on an actual highway location project in California. If successful we expect the procedures to have wide application in the "search and choice" phase of public facility location.

GRADUATE EDUCATION

The new programs of graduate education are beginning to reflect our concerted effort for interdisciplinary activities.

Faculty from the Departments of Ocean Engineering, Aeronautics and Astronautics, and Civil Engineering have developed their complimentary interests and capabilities in transportation systems to the point of cooperative instruction in the core courses and have reached an informal agreement upon a joint doctoral program.

The addition to our faculty of a lawyer, Professor Baram, and a political scientist, Professor Matthews, both having their first degrees in engineering, has enabled us to offer our students a limited program of study at the interface of engineering and public policy as seen from the engineer's point of view. Three new subjects have been added; 1.811, Law and the Social Control of Science and Technology; 1.812, Special Problems in Environmental Law and Regulation; and 1.82, Engineering and Public Policy.

Future educational and research activities in water quality systems modeling and management will be enhanced significantly by the award

to the Department of a five-year professional training grant by the Environmental Protection Agency. Professor Harleman will be Program Director assisted by Professor Marks. The grant provides funds for five traineeships per year for graduate students and partial support for a new faculty member in the field of ecological modeling.

Mushrooming legal constraints and worsening labor problems are producing a crisis in the ability of the construction industry to meet the accelerating national demands for new and renewed capital facilities. A Departmental committee under the leadership of Professor Frank Jones has studied this problem during the past year and has recommended that we develop a research and S.M. degree program in the Management of Capital Facilities Projects. We have begun by adding to the faculty as a part-time lecturer, Mr. Charles Helliwell, a consultant in project management. We plan a gradual introduction of research and instruction next year at a pace which is governed by the availability of resources and by the progress of our self-education.

At a time when graduate enrollments are declining across the country, the number of domestic applications for admission to our graduate program has increased for the second year in a row. At the same time we have voluntarily reduced the size of our graduate population to reflect both the increasing demands on our undergraduate programs and the effect of Institute-wide budget cuts upon the total resources available to us.

UNDERGRADUATE EDUCATION

The major achievement of this year has been the administrative implementation of the new undergraduate curriculum which was approved at the very end of the last academic year. Fourth-year students continued to operate under the old program, second-year students entered the Department under the new program and third-year students were given the option of choosing either program. Within the latter group there was an almost even selection between the two alternatives. The concept of "Primaries" in the new curriculum has created a mechanism for easily adjusting the Departmental programs available to our undergraduates. For example, the addition of a "Transportation Primary" during the early part of the fall term closed a gap which had previously been circumvented in an artificial way by means of the undesignated degree program. It is anticipated that other gaps in our present offerings may similarly be closed as they are identified.

Concurrent with implementation of the new curriculum we have also adopted a new advising system whereby each faculty advisor has responsibility for only a small number of students, typically no more than six.

This is an attempt to capture some of the individualistic flavor which we feel does much to make our graduate education such an exciting experience. For the aggressive student who does not hesitate to seek out faculty assistance the new system probably has little noticeable effect. However, real benefits are anticipated for the less aggressive students who will hopefully now receive a full measure of attention. In addition the Department may benefit simply through the increased number and variety of faculty contacts with our undergraduates.

Enrollment in our undergraduate programs continues to grow with classes undergoing significant enrollment increases well into the third year. We expect the Classes of 1972 and 1973 to grow to 50 students by the time they graduate which is a 50 per cent increase over the experience of recent years.

Another significant trend is the increasing number of out-of-department students enrolling in our undergraduate subjects. This has long been true in our computer systems subjects but now extends to introductory subjects in water resources, transportation systems, and engineering systems analysis as well.

EQUIPMENT AND FACILITIES

Formal dedication of the Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics took place on October 1 and 2 in conjunction with a symposium concerning "Water Environment and Human Needs." The new laboratory has doubled the floor space of the original Hydrodynamics Laboratory and provides not only additional space for light experiments but also classrooms, computer facilities, a water quality laboratory, a reading room and offices.

Through the efforts of Professor Wissa, a new data acquisition system has been made operational in the Soil Mechanics Laboratory. The system handles 200 channels, and the sequence and rate of readings is controlled by a special computer. The data are stored on magnetic tape, with provisions for simultaneous printed copy. Programs are available for computation and plotting, directly from the tapes, of data from most types of laboratory strength and consolidation tests. The first phase of a similar system has been installed in the Parsons Laboratory.

FACULTY CHANGES

Resignations have been received from Professor Russel Jones who becomes Head of the Department of Civil Engineering at Ohio State University; from Professor Stafford who is now (among other titles) Professor of Agricultural Economics at the University of Florida; and from

Professor Bromwell who goes into professional practice. Professor Odoni has transferred to the Department of Aeronautics and Astronautics.

New appointments include Assistant Professors Joseph Soussou, Wayne Pecknold and Brendan Harley. All hold M.I.T. doctorates. Professor Soussou is exploring the concepts of serviceability, maintainability and reliability of materials with respect to their structural uses. Professor Pecknold is interested in transportation demand modelling and Professor Harley is developing computer systems within the field of hydrology and water resource planning.

As mentioned earlier Associate Professor Michael S. Baram and Assistant Professor William H. Matthews have joined the faculty to work in the area of engineering and public policy.

Frank Jones, Ford Professor of Urban Affairs, has assumed the Directorship of M.I.T.'s new program of Community Fellows which has its base within the Department of Urban Studies and Planning.

HONORS AND AWARDS

Among the many notable individual accomplishments and recognitions of our faculty the following stand out:

Professor Harleman was awarded the Karl Emil Hilgard Prize of the American Society of Civil Engineers for his paper entitled "Dispersion in Homogeneous Estuary Flow."

Professor McGarry received the Air Force R.O.T.C. Outstanding Service Award for his work on behalf of the R.O.T.C. program at M.I.T. while serving as chairman of the M.I.T. R.O.T.C. Advisory Committee.

Professor C. Allin Cornell has been named a recipient of the Walter L. Huber Research Prize of the American Society of Civil Engineers.

PETER S. EAGLESON

DEPARTMENT OF ELECTRICAL ENGINEERING

During the year the administrative organization of the Department was modified to better cope with the broad range of activities spanned by its research and educational programs. Professors Wilbur B. Davenport, Jr. and Robert M. Fano were made Associate Department Heads, respectively, for Electrical Science and Engineering and Computer Science and Engineering. Each will be responsible for the administration and development of the curricula (undergraduate and graduate) in his area, and for the recruitment and professional development of younger faculty. All members of the faculty will continue to be members of the Department of Electrical Engineering and there will be no formal division

into two groups. Thus, there will be maximum future flexibility for the faculty both in regards to research and teaching activities.

As a result of the recent changes in the M.I.T. Administration, two members of our faculty have resigned — Professors Jerome B. Wiesner and Paul E. Gray — in order to assume new roles as President and Chancellor of M.I.T. Professor Walter A. Rosenblith has become Provost and James D. Bruce, Executive Officer of the Department has been appointed Associate Dean of the School of Engineering. The new Executive Officer of the Department is Assistant Professor Louis D. Braida.

Also during the year Professor Elias was named the first holder of the Cecil H. Green Chair, endowed by Mr. and Mrs. Cecil Green. Professor Campbell L. Searle has been named to succeed Professor Amar G. Bose as holder of the Clarence Joseph LeBel Chair. Professor Francis F. Lee was named a Fellow of the I.E.E.E. for his contributions to research, engineering, and education in the field of digital systems.

Professor Edward Fredkin has been named Director of Project MAC. He succeeds Professor Joseph C. R. Licklider who is returning to teaching and research activities in the area of Computer Graphics and Dynamic Modeling.

Professor Thomas S. Huang was awarded a Guggenheim Fellowship for 1971-72.

Professor Alan McWhorter received the 1971, I.E.E.E., David Sarnoff Award.

Professor James Roberge received the Best Paper Award at the 1970 Society for Information Display Symposium.

The past year was one of adjustment and anticipation. There was a feeling of waiting for the other shoe to drop in regard to the Federal support of research. By the end of the year, however, our total research support in the department had not decreased, although some individual groups had suffered partial reduction in support. Nevertheless it was becoming clear that there were shifting priorities among supporting agencies, and that in such areas as pollution control, energy systems, transportation, and health care announced shifts in national priorities had not yet been accompanied by shifts in fiscal appropriations. Thus, we enter the 1971-72 year with unresolved problems of how (and whether) to shift the foci of our various research groups. As in all periods of uncertainty, we find many of our faculty responding by serious and imaginative thinking that will hopefully lead us into new and important directions.

Student enrollment in the various Course VI programs continues high. Data on enrollment, degrees granted, and staffing are shown in Tables I, II, and III.

Table I Enrollment

	VI-1	VI-2	VI-3	VI-A	Total
Sophomores	117	—	64	—	181
Juniors	108	—	66	24	198
Seniors	179	28	9	22	238
Graduate		370		48	418

Table II Degrees

Bachelor of Science	208
Master of Science	122
Electrical Engineer	51
Doctor of Science and Doctor of Philosophy	49

Table III Composition of Faculty and Staff

Professors	54
Associate Professor	30
Assistant Professor	31
Professor Emeriti and Senior Lecturers	4
Lecturers	21
Research Associates	6
Instructors (Graduate Students)	13
Teaching Assistants	88
Research Assistants	111

The increasing number of students opting for computer science subjects has resulted in a shift in teaching load away from the "normal" electrical engineering subjects. However, about seven of the electrical engineering faculty, not generally identified as computer scientists, helped to carry the increased teaching load in the VI-3 curriculum.

COOPERATIVE PROGRAM (COURSE VI-A)

This year saw a reversal of the downward trend in interest and enrollment in the Department's Cooperative Program. The percentage of the E.E. class applying was 38 per cent (vs. 18 per cent in 1970) while the actual new enrollment moved to 17 per cent from 13 per cent last year. In actual numbers: 69 students applied this year vs. 39 last year; 31 were finally enrolled vs. 29 last year.

Two highlights of this year were the establishment of an "early admission" procedure for VI-A seniors applying to our Graduate School and the incorporation of the Hewlett-Packard Company into the Program.

The "early admission procedure" allows most VI-A seniors to know by November 30th if they will be admitted to our graduate school. This will allow for better planning on both the student's and company's part for the third and fourth sequential work assignments which, hopefully, will involve work leading to a graduate thesis.

In joining the Program the Hewlett-Packard Company brings work assignments in its Microwave Division in Palo Alto, California, and the Medical Electronics Division in Waltham, Massachusetts. This now gives our students both a chance to work on the West Coast and also in the developing area of electronics applied to medicine.

The plight of the electronics industry had its effects on other VI-A companies, however. The Air Force Cambridge Research Laboratories, which had not selected any new students last year, felt it necessary to withdraw completely from the Program this year. They could not budget ahead far enough in the foreseeable future to guarantee a student continuous employment to fullfill his entire VI-A obligation.

Other companies, though remaining on the Program were forced to cut back in selections.

There is considerable evidence that the student interest in VI-A will remain high and we are looking into the possibility of adding other companies to our VI-A list.

UNDERGRADUATE PROGRAMS

Program VI-1. A new subject in Electrodynamics (6.04) has been added to the undergraduate core in Electrical Science and Engineering. Subjects in Fields Forces and Motion (6.06) and Energy Transmission and Radiation (6.07) have been discontinued.

Program VI-2. No new sophomores were admitted to VI-2. The present Senior class will phase out the VI-2 program.

Program VI-3. Undergraduate enrollment in VI-3 appears to be stabilizing at one-third of total undergraduate enrollment. Work has begun on a new introductory subject in computer science to be offered in 1971-72.

Registration for Project Study (6.85X), extended participation in research or independent study at the undergraduate level, has remained at about the same level as last year. The character of the enrollment has changed significantly, however. Now the enrollment is chiefly underclassmen, whereas in previous years upper class enrollment had predominated.

A number of new elective subjects have been offered for the first time: Introduction to Digital Signal Processing (6.275), Pattern Recognition (6.31), Advanced Circuit Techniques (6.345), Animal Communication Systems (6.40) and Control Systems Project Laboratory (6.724).

The Department now offers more than one-fourth of the Institute Laboratory Subjects and nearly 30 per cent of the enrollment in Laboratory Subjects occurs in Course VI subjects.

Departmental staff and students participated extensively in the first independent activities period at M.I.T. The programs offered included

extensions and intensive versions of regular subject offerings and project laboratories, individual study and research opportunities for undergraduates, "how-to-do-it" skill acquisition courses, and a series of seminars on departmental research activities. Despite some organizational roughness associated with the experimental nature of the period, many of those who participated expressed a high level of satisfaction. In particular, the 240 people participating in the "how-to-do-it" were very enthusiastic. Professor Mildred Dresselhaus served as departmental coordinator of January I.A.P. activities.

GRADUATE PROGRAMS

The enrollment of full-time graduate students dropped slightly to 418 registered as of September, 1970, compared to 443 the previous year. We registered 141 new graduate students during 1970, 53 domestic students, 59 M.I.T. S.B. students, and 29 foreign students.

The Committee on Graduate Students, Chaired by Professor Campbell Searle, has recommended that the Department continue the quota of 430 full-time graduate students for 1971-72. The Committee has requested and received, from the Dean of the Graduate School, a special quota of 20 openings for VI-A students. This would mean a total graduate population in the Department would not exceed 455 students. We received 925 final applications for the academic year compared with 918 for the previous year.

Table IV lists all forms of financial support for our graduate students. Table V lists in more detail fellowships, traineeships, and outside support for U.S. and foreign students in the Department.

Notice that the research and teaching support declined about 18 per cent from the previous year. We expect that fellowship support will continue to decline for at least one more year as a result of these new Federal policies.

Table IV Financial Support for Graduate Students in the Department of Electrical Engineering for the Academic Year 1970-71

Type of Support	Number supported first term 1969-70	1970-71	Estimated number to be supported during first term 1971-72
Fellowships, traineeships, and outside support	168	176	170
Teaching assistants and instructors	120	99	95
Research assistants	135	111	111
Own funds	20	32	74
Total	443	418	450

Table V Fellowships, Traineeships, and Outside Support for U.S. and Foreign Students in the Department for the Academic Year 1970-71

Fellowships awarded by the Department:	
Grass Instrument Company Fellowship in Electrical Engineering	1
Boeing Company Fellowship	1
Industrial electronics (R.L.E.)	4
M.I.T. endowed fellowships	3
Schlumberger Foundation Fellowship in Electrical Engineering	1
Total	**10**
Government fellowships and traineeship awarded by the Department:	
National Aeronautics and Space Administration (NASA) Stipend only	2
National Defense Education Act (NDEA)	4
National Institutes of Health (NIH)	12
National Science Foundation (NSF) Traineeships	26
Total	**44**
Outside awards made directly to U.S. students:	
American Electric Power	1
Bell Telephone Laboratories	11
Canberra Industries	1
General Electric	1
Hertz Foundation Fellowships	7
IBM Resident Study Program and Fellowship	2
Lincoln Lab Staff Associates	2
MITRE Corporation	1
National Science Foundation (NSF) Fellowships	69
New York Commission for Blind	1
Radio Corporation of America	1
U.S. Army	1
U.S. Air Force	2
U.S. Coast Guard	1
U.S. Navy	2
Total	**103**
Foreign students supported by their country, industry, or international agencies	19
Grand total	**176**

The NSF traineeships awarded to the department for 1971-72 declined to 16 from the previous 26. In September, 1972, we anticipate only 8 NSF traineeships to be available and the traineeship program will terminate upon completion of these 8 awards.

About 8 years ago, the Department began its present suborganization into graduate "areas." These are: Area I, Systems Science and Control Engineering; Area II, Computer Science; Area III, Circuits and Signals; Area IV, Electrodynamics; Area V, Materials and Devices; Area VI, Communications and Probabilistic Systems; and Area VII, Communications Bio-Engineering.

The primary functions of these areas are to provide faculty counseling for graduate students and to assume responsibility for oral exams and

the students' general progress towards the doctoral degree. At present each Area has a chairman; these chairmen with a few other members at large constitute our Graduate Committee. As time has gone by the research activities in the various areas have shifted so that the formal names no longer describe their interests accurately, and there is considerable overlap. As we enter new areas of research, there is no obvious tie to the areas. Thus, the organizational structure of our graduate activities is an important item for the 1971-72 agenda. The question of whether graduate student quotas should be assigned to the Areas continues to arise. At present, we continue to admit students to the Department with no explicit consideration given to their stated areas of technical interest. Since students' interests change, and since many seniors are not yet sure of their interests, it is generally agreed that admission to the Department at large is most desirable. However, as Areas grow and contract in student interest, imbalances occur within the Areas, and the problem of how to deal with it is still under discussion.

DEPARTMENTAL RESEARCH ACTIVITIES

The activities of almost 600 people, faculty, graduate students, and postdoctoral students, can hardly be summarized in a few pages. However the broad outlines can be indicated.

With only a few exceptions, most of our research is carried on within the structure of the following large laboratories: Artificial Intelligence Laboratory; Center for Material Science and Engineering; Electrical Power System Engineering Laboratory; Electronic Systems Laboratory; Project MAC; and the Research Laboratory of Electronics. In addition, there are smaller numbers of electrical engineering faculty in the following: Center for Space Research; High Voltage Research Laboratory; Laboratory for Insulation Research; Operations Research Center; Particle Optics Laboratory; and the Strobe Laboratory. Further diversity is provided by participation in the research programs of the National Magnet Laboratory, Lincoln Laboratory, the Eaton-Peabody Laboratory of the Massachusetts Eye and Ear Infirmary, and the Thorndike Laboratory of Boston City Hospital.

In the following, the major foci of research by Department of Electrical Engineering members are listed by brief title in order to give a better overview of the range of activities.

ARTIFICIAL INTELLIGENCE LABORATORY

Design and implementation on the Planner language, which is a step in the direction of permitting one to state what he wants done rather than specifying a procedure for doing it; system for controlling external real-

time machinery at remote time-shared terminals; visually controlled manipulator; study of the semantics of natural languages; application of theory of intelligence to education of children.

CENTER FOR MATERIALS SCIENCE AND ENGINEERING

Amorphous semiconductor physics and display devices; tin oxide crystals and possible high temperature semiconductor devices; lead salt physics and electro-optical devices; crystal growing physics and technology; magneto-elastic wave propagation and signal processing devices; dark trace displays; pressure tunable lasers; surface sterilization by laser (CO_2) radiation, and related physics; automatic sorting of trash by acoustic and spectroscopic "signature"; micro-electronics process and device research; fundamental electronic properties of semiconductors and metals.

ELECTRICAL POWER SYSTEMS ENGINEERING LABORATORY

Super conducting field turbo-alternator; physics of contamination flashover; new wide band transmission line simulator; acoustic noise from EHV lines; developing $10^6/1$ scaled rotating machines dynamically equivalent to large turbo alternators.

ELECTRONIC SYSTEMS LABORATORY

Project INTREX Library information system; cockpit display of ground-based radar data for air traffic control; high resolution synthetic aperture radar; study of CATV system; new hardware-software systems for computer interconnections; remote entry and time sharing; design of highway traffic control system for Straight-Creek Tunnel in Loveland Pass, Colorado; Implicit Computation, new class of computers for high speed and high accuracy solutions to large scale problems described by many coupled equations; division of control sciences including theory of optimal control, hierarchical systems, adaptive stochastic control, distributed parameter systems, decentralized systems, and game theory, applications to control of power networks, chemical process plants, traffic control, and socio-economic systems.

PROJECT MAC

Combinatorial and statistical analysis algorithms; study of subclasses of Petri nets; properties and design of asynchronous modular logical circuits; definition of a common base language that can serve as a target representation for procedures translated from a variety of practical source languages; protection of privacy in a multi-access computer system; dynamic reconfiguration of a multi-processor, multi-memory computer system; definition and implementation of an input-output programming

language; automatic management of a multi-level memory system; system programming languages; design and implementation of an interface to the ARPA network; design and development of a computer system to facilitate the modeling and testing of complex ideas. A variety of graphical techniques have been developed for this purpose; further development of the MACSYMA system for interactive algebraic manipulation. This system has been used for research on various topics such as dispersion in linear systems, statistical mechanics problems, and quantum mechanical calculations. The system has been extended to include capabilities for computing limits and improper integrals; model of language extension in terms of which the semantics of new constructs can be specified; properties of canonic systems and their relation to formal grammars; complexity measures for programming languages.

RESEARCH LABORATORY OF ELECTRONICS

Plasma Physics — Beam-plasma discharges; plasma heating by lower-hybrid excitations; direct energy conversions from high temperature plasma flow to ac power; plasma thrustors for satellite keeping; joint participation in development of ALCATOR a new high performance toroidal plasma device; solid state plasma amplifiers and active delay lines. Lasers — CO_2 dc and transverse electrode high pressure lasers; production of short pulses and theory of non-linear behavior, mode locking. Radio Astronomy — Development of mm spectrometer package for Numbus 5 and 6 for continuous monitoring of atmospheric profiles of ozone, oxygen, and water vapor. Development of low-noise solid state devices for 60 GHz receivers. Communications — Optical communication systems: ground to ground, ground to satellite, and satellite to satellite; estimation theory, detection, and application to oceanography; sequential decoding theory and systems; digital data transmission; application of information theory to problems of information storage and retrieval in computers. Speech — Acoustic manifestations of speech; machine recognition of speech; homomorphic filtering; digital processing of speech signals; development of a system for converting English text to speech. Hearing — Psychophysical studies of binaural hearing, pitch discrimination, intensity resolution, short-term memory, masking, and speech impairments; development of more effective hearing aids; communications biophysics and auditory physiological studies of the detailed functioning of the auditory system from the outer ear to the nervous system. Sensory Aids — A reading machine for the blind; tactile pitch feedback for the deaf; automatic Braille transcription; time-shared console for the blind, with speech output. Optical Systems — Digital facsimile systems for newspaper use or for wire transmission of X-ray photo-

graphs; image enhancement; computer generated holograms for signal processing; bio-medical engineering; development of quantitative microscopy for study of blood and the automatic classification of anatomical features (color, size, shape, internal structure, adhesiveness) of its compotents; ultrasonic diagnostic systems; study of perceptual errors in X-ray reading; clinical instrumentation for cardio-vascular and renal care and monitoring; health delivery systems. Audio and Electronic Engineering — Wide dynamic range magnetic recording systems; room acoustics; the use of perceptual phenomena in the design of practical hi-fi systems; computer-aided network analysis.

HIGH VOLTAGE RESEARCH LABORATORY

Clinical study and treatment of cancers by 2-3 Mev electrons and/or X-rays; development of Dermatron — a compact Mev source for treatment of tumors near the skin; absolute electron dosimeter; study of compressed gas insulation for high voltage underground power cables.

LABORATORY FOR INSULATION RESEARCH

Wide range dielectric spectroscopy for study of molecular systems in H_2O; new techniques for blood preservation.

PARTICLE OPTICS LABORATORY

Development of scanning ion microprobe for study of surface and trace impurities; measurement of electron impact ionization parameters of metal atoms; electron beam testing of large scale integrated circuits.

STROBE LABORATORY

Primarily devoted to undergraduate instruction and research in high intensity flash techniques for photography; special sonar units for exploration of water bottoms and river beds.

SYSTEMS ENGINEERING AND OPERATIONS RESEARCH

Studies of urban police patrols, urban service systems, automobile licensing and insuring systems, emergency ambulance systems; formal theories of large scale systems.

FACULTY CHANGES

APPOINTMENTS

Edward Fredkin, formerly vice-president for advanced development at Information International Incorporated, was appointed Professor of Electrical Engineering and Director of Project MAC.

Sanjoy Mitter, Associate Professor of Electrical Engineering at Case

Western Reserve, was appointed Associate Professor. During the previous year Professor Mitter was a Visiting Associate Professor at M.I.T. He continues as a member of the Control Theory Group and is involved in the development of new graduate subjects in system theory.

Appointed Assistant Professors after receiving doctorates from M.I.T. were Drs. Clifton G. Fonstad, who is interested in the electron device applications of stannic oxide, Paul W. Hoff, whose research interests focus on carbon dioxide lasers and modern optics, Suhas S. Patil, who is interested in computation structures and systems, Colin G. Whitney, whose research interests lie in the field of semiconductor laser modulation and scanning, and Patrick H. Winston, whose research is concerned with heuristic programming and artificial intelligence. Professors Hoff and Winston held simultaneous appointments as Vinton Hayes Postdoctoral Fellows in Electrical Engineering.

Dr. Patrick E. O'Neil, who received the S.B. degree from M.I.T., the S.M. from the University of Chicago, and the Ph.D. from Rockefeller University, joined the faculty this year as Assistant Professor of Electrical Engineering. His interests lie in the field of computational complexity and the analysis of algorithms.

RESIGNATIONS

Professor Herbert H. Woodson resigned his appointment in order to join the staff and head the Department of Electrical Engineering at the University of Texas.

Professor Arthur Evans, Jr. resigned to become a staff member of Lincoln Laboratory.

Assistant Professor Robert Ross Fenichel resigned to accept employment in industry.

Assistant Professor Martin E. Hellman resigned in order to accept an appointment at Stanford University.

Assistant Professor William J. Ince resigned in order to return to the full-time staff of the Lincoln Laboratory.

Assistant Professor Colin G. Whitney resigned to accept employment with the Isomet Corporation.

VISITING FACULTY

Visitors to the Department during the past year include:

Dr. Stephen C. Baer who worked with Professor Minsky in Project MAC on problems associated with the simulation of neuronal activity in nerve tissue.

Professor Woodrow W. Bledsoe, of the Department of Mathematics and Computer Science at the University of Texas in Austin, spent the

academic year as a Visiting Professor associated with the Artificial Intelligence Laboratory.

Dr. Ivan M. Bortnik, of the All-Union Electrotechnical Institute in Moscow, U.S.S.R., spent the academic year with Professor Trump in the High Voltage Laboratory investigating the electrical insulating properties of heavy gasses.

Dr. Laurent G. Caron, Assistant Professor at the University of Sherbrooke, Sherbrooke, Quebec, worked with Professor Pratt at the Center for Materials Science and Engineering during his one-month appointment as Visiting Scientist.

Dr. Peter H. O. Eisenberg, of the research staff of the Technische Universitat, Berlin, spent the year as a Visiting Engineer associated with Professor Weizenbaum of Project MAC, working on problems in the area of computational linguistics.

Dr. Vuk Fatic, an Assistant at the University of Novi Sad, Yugoslavia, worked as a Visiting Engineering with Professor Melcher on problems in electromechanical systems theory.

Robert C. Folweiler, group leader at the MITHRAS division of Sanders Associates, spent the second term as a Visiting Scientist associated with Professor Epstein at the Center for Materials Science and Engineering. He was concerned with problems relating to chemical vapor deposition and the preparation of high purity feed materials.

Dr. Udaya S. Ganguly of the Jadavpur University, who had been a Postdoctoral Fellow associated with the Electronic Systems Laboratory, was a Visiting Associate Professor during the summer session of 1970. He taught a subject in electronic devices and modeling.

Dr. Wolfhard Hovel, a Scientific Assistant at the Technische Universitat of Berlin, was a Visiting Engineer associated with Professor Pratt. He worked on high frequency problems in quantum electronics.

Kjell J. Kloster, a research engineer and project leader at the Michelsen Institute, was associated with Professor Gould as a Visiting Scientist in the Decision and Control Science Group of the Electronics Systems Laboratory.

Adolf P. Zambran, Senior Lecturer at the Latvian State University, was associated with Professor Melcher and studied problems of electrodynamics in two-phase systems as a Visiting Scientist.

LEAVES OF ABSENCE

Professor Richard B. Adler spent the first term on sabbatical leave.

Professor Gordon S. Brown spent the second term on sabbatical leave.

Professor John V. Harrington spent the second term on sabbatical leave consulting on communication system problems for industry.

Professor Samuel J. Mason spent the first term on sabbatical leave in industry.

Professor George C. Newton spent the first term on sabbatical leave at Lincoln Laboratory working on air traffic control problems.

Professor Alvin W. Drake spent the year on sabbatical leave at Harvard University, in connection with the Public Policy program, and the Graduate School of Public Affairs of the University of California at Berkeley.

Professor Robert M. Graham, while on leave of absence, held an appointment as Visiting Associate Professor in the Department of Computer Science at Berkeley.

Professor Chung L. Liu held an appointment as Visiting Associate Professor in the Applied Mathematics Division of Harvard University while on leave of absence.

Professor Thomas F. Weiss spent the first term on sabbatical leave at the Eaton-Peabody Laboratory of the Massachusetts General Hospital, continuing his experimental research in auditory function.

Professor Richard N. Spann spent the year on leave of absence at Applicon Inc.

Professor Jan C. Willems spent a year on leave of absence as a Senior Research Fellow on the Department of Applied Mathematics and Theoretical Physics, Cambridge University.

LOUIS S. SMULLIN

DEPARTMENT OF MECHANICAL ENGINEERING

During the past year our undergraduate enrollment dropped slightly. This is contrary to what were our expectations in view of the heavy involvement of the Department in activities of great interest to the younger generation, namely problems of air, water and noise pollution, various facets of biomedical engineering, and problems of urban and high-speed intercity transportation. We believe that as these directions of the Department become better known our undergraduate population will increase. The registration for Course II-A, which leads to the undesignated degree of bachelor of science now seems to have reached a steady proportion of about 30 per cent of all juniors and seniors. It is now a well-known and popular route toward an undergraduate background in engineering.

The graduate population has stood up remarkably well in view of the decrease in research assistantships and fellowships available and also in

view of the contracting job market for highly trained engineers. Perhaps the most notable change is the reduction in the number of students attempting the qualifying examinations for the doctorate. Whether this is a temporary phase or a more permanent situation cannot now be foretold. For the country as a whole it certainly appears that at least for a decade there will be sharp contraction in the number of Ph.D.'s in engineering, but this need not be true for individual schools such as M.I.T. which act as lodestones for students desiring advanced work of the highest quality.

The principal facilities changes were: the acquisition of a scanning electron microscope which will be an important asset to several research groups in the department; and the move onto the campus of the Center for Sensory Aids Evaluation and Development, which will lead to an easier and closer connection between academic thesis work and industrial-level product design and development.

The undergraduate honorary fraternity, Pi Tau Sigma, was notably active during the year. It prepared a catalogue of undergraduate subjects giving much information of vital practical interest to students that normally does not appear in the M.I.T. catalogue. In addition, it undertook the ambitious task of extending the evaluations of subjects and of instructors to every subject given, both undergraduate and graduate. These evaluations are of the highest importance to the department, both in helping the faculty to improve themselves and their subjects of instruction, and in helping the department and the administration to encourage and recognize high quality in teaching.

Among the undergraduate subjects, the following were notable either for innovations of style or for the nature of the subject matter. Professor Thomas J. Lardner, in Mechanics of Solids (2.01), employed a concentrated study program in which the students studied this subject exclusively for one-third of the term. Professors Ernest G. Cravalho and John P. Appleton introduced a new undergraduate subject, Introduction to Molecular Thermodynamics (2.404). Professors Cravalho and Borivoje B. Mikic offered for the first time Biomedical Heat and Mass Transfer (2.52). Professor David G. Wilson, in Urban Laboratory in Mechanical Engineering (2.67T), and his students designed and constructed a personal-transit dual-mode cable car system as part of the demonstration of a possible means of access to a recreational area in Boston harbor. In Engineering Synthesis and Design (2.70), Professor Igor Paul had the students working on a project involving the automation of post office services. Professor John B. Heywood introduced a new freshman seminar on "Controlling Pollution: Technological Prospects," while Professor Robert W. Mann offered a policy seminar, "Production,

Development and Market Penetration of Biomedical Engineering Devices and Processes."

Notable among new graduate subjects of instruction were the following. Professor Richard H. Lyon in collaboration with Professor Patrick Leehey of the Department of Ocean Engineering and Professor Sheila E. Widnall of the Department of Aeronautics and Astronautics offered the new joint subject Principles of Acoustics (2.060J)/(13.81J)/(16.091J). In Modelling and Simulation of Dynamics Systems (2.141), Professor Henry M. Paynter laid emphasis on the potential of applied analog/digital/hybrid computations, using the special facilities we have in the department. Professors Ronald F. Probstein and Ain A. Sonin offered Desalination and Water Purification (2.284). In Quantum Thermodynamics (2.47J)/(22.58J), Dr. George N. Hatsopoulos collaborated with Professor Elias P. Gyftopoulos of the Department of Nuclear Engineering. Similarly, Professor Warren M. Rohsenow collaborated with Professor A. Douglas Carmichael of the Department of Ocean Engineering, offering Thermal Power Systems (2.601J)/(13.26J). Professors Mann and Paul, together with Dr. Eric L. Radin of the Harvard Medical School and Children's Hospital, offered Biomechanics (2.75), while Professor Padmakar P. Lele introduced Biological Effects and Medical Applications of Non-Ionizing Radiations (2.77).

Among the interesting and significant research efforts were the following. Professor Stephen H. Crandall and his students continued their research on vibration of complex structures due to seismic and acoustic excitation. Professor Lyon initiated studies on the acoustics of buildings and on the impact of V/STOL aircraft operations in urban areas. Professor Nam P. Suh's work on the enhancement of surface properties of carbide tools by oxide treatments has led to the significant finding that the tool life increases by a minimum of 30 per cent. The work of Professors Heywood and James C. Keck on the origin of hydrocarbon emissions and on the prediction of nitric oxide and carbon monoxide emissions has received wide attention in the automotive and gas turbine industries. Professors Probstein and Sonin now have a major program in water desalination with emphasis on two methods, electrodialysis and reverse osmosis. Professor C. Forbes Dewey, Jr.'s development of a wave-length tunable infrared laser has attracted wide attention. Professor James A. Fay has initiated a research project on aquaculture under the sponsorship of the Maine Department of Sea and Shore Fisheries. Professor Wilson's research on the automatic sorting of solid-wastes for reclamation has progressed to the pilot plant stage. Professor Paul and Dr. Radin have made novel and interesting inroads into the understanding of the mechanism of degenerative arthritis. In connection with the Operations Re-

search Center and its project on "Citizen Feedback," Professor Thomas B. Sheridan has developed a computer-aided communications technique for conducting group meetings and polling opinion very rapidly.

The faculty as in past years received many signs of recognition, among which the following are notable. Professor Jacob P. Den Hartog was made a Foreign Member of the Royal Netherlands Academy of Arts and Sciences, and he gave the Robert Henry Thurston Lecture at the 1970 Winter Annual Meeting of the American Society of Mechanical Engineers. Professor Fay was elected a Fellow of the American Institute of Aeronautics and Astronautics and continued to serve as Chairman of the Air Pollution Control Commission of the City of Boston. Professor Mann received the signal honor of election to the newly created Institute of Medicine of the National Academy of Sciences. Professor Egon Orowan received the Vincent Bendix Award of the American Society for Engineering Education. Professor Probstein received the Freeman Scholar Award in Fluid Engineering of the American Society of Mechanical Engineers. Professor Herbert H. Richardson was on leave of absence during the year to serve as Chief Scientist of the U.S. Department of Transportation. Professor Rohsenow will receive the Max Jakob Award of the Heat Transfer Division of the American Society of Mechanical Engineers. Professor Sheridan was elected a Fellow of the Human Factors Society. Professor Robert E. Stickney received the Western Electric Fund Award for excellence in instruction of engineering students, and was also elected a Fellow of the American Physical Society.

ASCHER H. SHAPIRO

DEPARTMENT OF METALLURGY AND MATERIALS SCIENCE

This year has seemed to be one of return to normal pursuits after the occasional disruptions of the previous year. Perhaps the calendar change, which compressed the first term, had some influence in keeping everyone busier than before. This was also the year in which the M.I.T. Commission presented its final report, recommending some significant changes in undergraduate education. A number of faculty members interacted with the Commission and associated study groups which were formed to digest the report.

The most striking product of the new calendar, the January Independent Activities Period, was rated a success by both faculty and students. The many offerings by the Department during January drew a total of about 100 students, mostly undergraduates. Among the most successful

offerings were a compressed version of the subject "Techniques of Metal Sculpture" and an innovative excursion into metallographic laboratory techniques developed by Professor Witt in collaboration with a number of his colleagues.

The Undergraduate Curriculum Committee, chaired by Professor Cohen, presented its final report in January and it was generally agreed that the attempt should be made to implement its recommendations as soon as possible. Among the changes proposed by the Committee was the separation of all laboratories from subjects of instruction and their consolidation into three principal laboratory subjects. A more controversial recommendation is that most of the required subjects in the Departmental curriculum be 8 rather than 12 units. It is probable that this aspect of the Committee's recommendation will have to be given further study.

At a meeting of the Corporation Visiting Committee for the Department in February the proposed changes in the undergraduate curriculum were presented and drew mostly favorable comment though there were some reservations with regard to the larger number of required subjects. The Visiting Committee also engaged in an animated discussion of the future direction of this interdisciplinary field of materials science, a timely topic in view of the forthcoming study to be sponsored by the National Science Foundation and the change in attitude towards government-sponsored research in materials. The pattern that is emerging within the Department is that research which involves readily visualized applications is on the increase. For example, work in biomaterials is springing up rapidly and an expanding effort in polymer research is developing. Interest in recycling and waste disposal problems has also developed though not yet to the extent of a sponsored research program.

UNDERGRADUATE INSTRUCTION

Introduction to Solid State Chemistry, 3.091, continued to attract a large number of freshmen. Professor John Wulff was aided by Professor Kenneth C. Russell in teaching the subject in the Fall and Professor Witt, aided by Professors Johnson and Wuensch taught the subject in the spring. Recitation sessions were more readily handled this year because of the appointment of a number of additional teaching assistants.

Further development of the project-type laboratory associated with 3.141, Science of Materials, was made by Professor Pelloux. The third large undergraduate offering which is not for students within the Department, 3.19, Techniques of Metal Sculpture, was again oversubscribed.

A new undergraduate subject, 3.101J, Biomedical Materials, was offered jointly under the direction of Professors Robert M. Rose and I. V.

Yannas of Mechanical Engineering. Drs. W. G. J. Putchar, E. L. Radin and A. L. Schiller also took part in the teaching.

An interesting development in the sophomore laboratory, 3.05, Materials Research Laboratory, is the number of students who would like to work in the archeological metallurgy laboratory. Miss Heather Lechtman has been very accommodating and some rather interesting projects have resulted. The AMAX Foundation Prize for the best laboratory report in this subject was shared among Miss Cynthia DuPont, for a study on potsherds using the scanning electron microscope, Mr. Ernest L. Hall, Mr. Robert A. Cava and Mr. Patrick L. Martin.

The Dow Chemical Company prize for the best undergraduate thesis was awarded to Miss Elaine Savage for a study, also done in the archeological metallurgy laboratory, of Japanese swordguards. The Metallurgy and Materials prize for the outstanding junior went to Thomas W. Eagar.

Undergraduate seminars involving 50 students were offered by Professors Bever, Johnson and Ogilvie. Undergraduate enrollment was down somewhat at 49, with 8 students registered in the 3A program for the undesignated degree. Fifteen bachelor's degrees were awarded and, as in the previous year, a number of students elected to continue for the S.B.-S.M. program.

GRADUATE INSTRUCTION

The subject 3.44, X-ray and Crystal Physics, offered by Professor Averbach has aroused enough interest that a sequential subject 3.45T, X-ray Diffraction, will be introduced. Professor Uhlmann's subject, 3.66, Materials Science of Polymers, will become part of a graduate sequence for students who are primarily interested in polymers, a sequence which will be offered on an interdepartmental basis. Other subjects in the sequence are offered by the Departments of Civil, Mechanical, and Chemical Engineering.

A study of the minor program was completed by a committee chaired by Professor Bever and recommendations for changes in the existing pattern will allow more flexibility in satisfying the minor requirements.

Graduate student enrollment was slightly lower at 133 regular students and 3 special students. Advanced degrees awarded included 13 Master's degrees, 1 Engineer degree and 19 doctoral degrees. The last figure is the lowest total for some time but it is expected that it will be followed by a much higher figure than normal next year.

GRADUATE RESEARCH

Since full descriptions of the research programs are given in the *Annual Report of Research in Materials Science and Engineering*, only a short

summary is given here. It should be emphasized that not all of the research projects are covered, but the summary does give some idea of the variety of projects that graduate students elect to work on.

PHYSICS OF SOLIDS Professors B. L. Averbach, R. Kaplow, K. H. Johnson, D. J. Sellmyer. Work on magnetic materials has continued with magnetic neutron scattering measurements on single crystals of cobalt oxide. The localized magnetic structure has been studied in some detail and spin correlations of out to 50 neighbors have been obtained. Other work on magnetic materials has dealt with the magnetic susceptibility of fine particles produced by splat cooling as compared with mechanically processed powders. This work is confined at the moment to the structure of rare earth-cobalt compounds.

The structure of amorphous and crystalline selenium-arsenic alloys has been investigated by X-ray diffraction and it appears that the structure of amorphous As_2Se_3 is closely related to that of the crystalline compound. The structures of a number of amorphous semiconductors are also being determined by means of X-ray diffraction; both memory and switching types of semiconductors are being examined. Earlier work of this group on the structure of metallic liquids has now evolved into a fundamental study of other liquids including water and solutions of hydrochloric acid. The near neighbor correlations in water seem to be strongly affected by the presence of other ions.

The radial distribution function of amorphous SiO has now been measured and, contrary to earlier results, it appears that SiO is not describable as a mixture of amorphous SiO_2 and Si.

A high vacuum electron spectrometer has been assembled to measure the intensity and energy distribution of electrons emitted in response to ultraviolet excitation. Metal and alloy surfaces will be examined under various controlled conditions.

Fermi surface techniques such as the de Haas-van Alphen effect are being used now to investigate metallic compounds with complex structures and the electronic states associated with dilute impurities. Work on solids in high magnetic fields has also continued and transport and quantum oscillatory measurements are being done both in the 100 kG superconducting solenoid and in fields up to 220 kG at the Francis Bitter National Laboratory. Materials studied have included beryllium and graphite.

Theoretical solid-state studies have been continued and the electronic structures of intermetallic compounds, of polyatomic and macromolecules, including methane and the molecular ions ammonium, sulphate and perchlorate have been determined. A new model has been developed

for calculating the localized electronic states of impurities in crystals. A self-consistent field theory for chemisorption of atoms and small molecules by transition metals has also been developed. Applications to biochemisorption and bio-catalysis by transition metals in enzymes are also planned.

PHYSICAL METALLURGY Professors M. B. Bever, J. W. Cahn, M. Cohen, J. F. Breedis, K. C. Russell. The enhancement of self-diffusivity during plastic deformation has been quantitatively explained on the basis of pipe migration along moving dislocations and it now seems likely that the diffusivity of interstitial atoms, such as carbon in iron, can also be increased by furnishing extra dislocation paths.

Work on martensitic transformations has continued and models have been developed to take into account possible autocatalytic effects in isothermal martensitic transformations. Small particle experiments are underway to minimize these autocatalytic effects and to concentrate on the initial rate of nucleation arising from pre-existing nucleation sites in the parent phase. These preexisting sites are subject to control by exposing the parent phase to high magnetic fields prior to the transformation. In collaboration with Professor Kaplow, Mossbauer investigations on virgin martensites produced by splat quenching in very high-carbon iron-carbon martensites will be conducted to determine whether the trapped carbon atoms are randomly arranged. Experiments have also been devised to check the prevailing order-disorder theories regarding the relationship between tetragonal and cubic martensites. The formation of the hexagonal closed packed (ϵ) and body-centered cubic (α) structures in pure iron under high pressure conditions, as well as the morphological aspects of martensitic transformation in these structures at atmospheric pressure has been reviewed. It is concluded that the unique features of the α martensite formation are not dependent upon the presence of the ϵ phase.

Massive transformations below 200°C in silver-cadmium alloys are being studied to provide a test of a transformation model which has already been developed. The measurements indicate linear growth rates without any detectable delay times, which is in contrast to the observations on copper-zinc alloys and suggests further refinements of the model.

Work on strain-hardening at very large plastic deformations has now been extended to titanium base alloys and it would seem that the process of cell formation within the grains that is involved in the strengthening of iron-base alloys is much less pronounced in hexagonal close-packed titanium; a different strain-hardening process may be operating.

In a study of the deformation of ruthenium single crystals it has been

shown that the arrays of screw dislocations found in titanium, zirconium and beryllium do not appear after prism slip in ruthenium; rather, pronounced edge braids are found and the dislocation structure of ruthenium is thus nearly identical with that found in magnesium.

Further measurements have been made of the heats of formation of crystalline and amorphous selenium-tellurium alloys so that the system has now been covered from 5 per cent to 90 atomic per cent tellurium. Heats of crystallization have also been measured on these alloys by differential scanning calorimetry. Work on heats of formation has also been extended to crystalline and amorphous alloys in the system As_2Se_3-Sb_2Se_3. The relaxation of amorphous selenium-tellurium alloys containing between 5 and 30 atomic per cent tellurium has been investigated by differential scanning calorimetry and small angle electron scattering; of particular interest is the glass transition temperature.

Work on solid-state kinetics has continued and a study of the precipitation of a cobalt rich phase from a copper rich, copper-cobalt alloy has been completed. The precipitation rates on grain boundaries, dislocation lines, and random lattice sites are in good agreement with the theories of nucleation for these phenomena. Professor Russell, in association with Drs. Aaronson and Kinsman of the Ford Scientific Laboratory has developed equations for obtaining the driving force for nucleation from solution models and phase diagram data.

Nucleation of voids, a problem in reactor materials, has been considered in terms of linked-flux analysis and rate equations for void nucleation under reactor conditions have been developed. This should help in the specification of design criteria to minimize void formation in actual reactors.

An example of a very fast solid-state reaction is that of the massive transformation of a $\beta \rightarrow \alpha$ brass. A double-bank, capacitor-discharge pulse heater has been used to initiate massive growth in the single phase α region followed by a pulse into the two-phase region. Within the accuracy of the experiment the massive reaction seems to cease at the $\alpha/\alpha+\beta$ boundary. The theory of coarsening, or Ostwald ripening, for sparingly soluble compound precipitates, such as oxides dispersed in a metal, has now been developed and is presently being tested in a series of experiments on copper alloys containing dispersed SiO_2 particles.

HIGH TEMPERATURE METALLURGY Professors N. J. Grant and R. M. N. Pelloux. Excellent low and high temperature properties have been obtained using finely atomized nickel-base powders containing an oxidizable element such as aluminum or beryllium. By comminuting to micron-thick flakes a coating of alumina or beryllia is formed on the powders

which are subsequently consolidated. Nickel-base alloys containing titanium have also been internally carburized with the idea that the titanium carbide hard-particle dispersoids would develop some bonding between particles and matrix. High strength values have been achieved at room and intermediate temperatures with good stress rupture properties at 1000°.

Inert gas atomized copper-zirconium alloys have been compacted by hot extrusion and tested for strength and ductility. Refinement of the structure by the use of quenched powders permits a higher zirconium content alloy with improved, low-temperature properties and there is excellent retention of structure and property stability after heating for one hour at 700°.

Work on splat cooling has continued with a study of the decomposition of metastable, solid solutions of aluminum supersaturated with such transition metal elements as copper, manganese, iron, nickel and cobalt. The maximum solute content is increased as much as 20 times by the splat cooling technique. A commercial aluminum alloy has been splat cooled to coarse flakes and extruded at 300°C. Compared to ingot material, in which intermetallic phases, up to 20 microns in size, lead to poor fatigue life, the near micron particles in this material contribute to the strength of the alloy with no loss of ductility, and fatigue life is increased by 5 to 7 times over the ingot product.

The corrosion-fatigue resistance of aluminum-zinc-magnesium alloys in a sea water environment has been studied as a function of the aging heat treatment. There is no significant difference in the sea water corrosion-fatigue strength whether the alloy is underaged, peak-aged, or overaged; this is in contrast to the stress-corrosion resistance in the overaged condition. A detailed evaluation by scanning electron microscopy of the characteristic fatigue-fracture features in aluminum alloys has been completed. The scanning electron microscope gives a more realistic view of the complexity of the fracture process although the extensive amount of secondary cracking thus revealed has not been fully accounted for.

ELECTRON OPTICS Professor R. E. Ogilvie. The electron microanalyzer has been used to determine nickel and carbon concentration profiles in a number of meteorites selected from different classifications based on the bulk nickel content and the cooling rate. This work has been facilitated by the development of an automated stepping system for the microanalyzer. The scanning electron microscope has also been used to perform non-dispersive X-ray analysis. A lithium drifted silicon detector and a gas flow proportional counter are being used to detect X-ray

signals generated. Analyses of phases in dental amalgam have been performed and it should eventually be possible to analyze microtome sections of biological material with a resolution of 1000Å.

An electron energy analyzer is being built for installation in a commercial 100 KV electron microscope. The objective is to develop higher resolution microanalysis, on the order of 100Å.

The hot stage developed earlier for the scanning electron microscope has been used to study the kinetics of sintering of metallic microspheres and has also been adapted for the study of pearlite transformations in steels.

CHEMICAL AND PROCESS METALLURGY Professors P. L. de Bruyn, J. F. Elliott, T. B. King, B. H. Rosof, H. H. Uhlig, J. B. See. A number of studies on heat and mass transfer in process metallurgy systems have been started. The thermal conductivity of slags containing appreciable concentrations of ferrous ions is being measured by a new technique wherein the temperatures at two points within the specimen are monitored by thermocouples which respond to a sinusoidal fluctuation of temperature at one surface. The phase shift of the thermal wave between these two positions can be related to the thermal conductivity.

A study of the conditions of heat flow and shape of a dendrite has shown that the assumption of steady-state flow is not realistic except in the case of very large ingots. A further study of convective motion in the interdendritic liquid of a partially solidified ingot has now been completed and it has been shown that the interdendritic channels which are finally left in the solid are an important feature in certain types of segregation.

The study of temperature distribution in graphite electrodes for electric-arc furnaces has now been completed and there is reasonable agreement between calculated temperatures and actual measurements obtained in a large operating furnace. A study of temperature distribution in electroslag remelting has also been completed and calculated temperature distributions in the ingot have been compared with experimental measurements. The melting of the electrode can be treated as a simple process of ablation.

Work has been initiated on the factors influencing the spreading of molten metals on solid metal substrates, which is of interest in many joining processes. Initial results indicate that heat flow in the substrate, the superheat temperature of the melt, and the surface tension are important factors.

In a joint study with Professor Flemings' group, the course of reaction between aluminum and oxygen during solidification is being studied to

determine if the oxide particles formed can be transported by buoyancy forces or by the movement of the solid-liquid phase boundary.

Work on the thermodynamic properties of carbon in solid iron-nickel-carbon, iron-silicon-carbon, iron-manganese-carbon, iron-molybdenum-carbon and iron-chromium-carbon alloys has been completed and the results are being prepared for publication.

The dissolution, surface and transport properties of hydroxyapatite and related materials are being investigated. Understanding the role of the fluoride ion in these materials is important because of its protective action against dental caries. It has been shown that the rapid uptake of fluoride ion by hydroxyapatite is due to surface bonding and the kinetics of the exchange reaction are now being studied.

The program of research in the corrosion laboratory has included studies of the critical potentials below which corrosion pitting of copper-nickel alloys does not occur and the effect on these potentials of environmental and metallurgical factors. Experiments to differentiate between various proposed methods of stress corrosion cracking have also been devised. The effects of stress, heat treatment, and factors concerned with the aqueous solution on corrosion fatigue of low and high strength steels have also been studied. Research on passivity has continued with a study of the structure of the passive film and further work on thin film oxidation kinetics, involving the marked effects of gaseous pretreatment, has been completed.

METALS PROCESSING Professor M. C. Flemings. Research on crystal growth has included a study of the growth of composite crystals and of crystals grown under conditions of extremely vigorous fluid flow. An apparatus is employed which can achieve velocity gradients at a solidifying interface of the order of 10^5/sec. For such velocities there are significant influences of the flow on structures.

The results of continued research on macrosegregation during ingot solidification show that most commercially important types of macrosegregation result from the flow of solute-rich liquid between dendrites in the liquid-solid region. The driving forces for the flow are solidification contraction, thermal contractions of liquid and solid, and gravity. The deformation and flow behavior of partially solidified alloys is now being studied, one practical objective being to examine the conditions necessary to develop a process which would permit casting alloys in a semi-solid state.

ELECTRONIC MATERIALS Professors H. C. Gatos, R. M. Rose and A. F. Witt. The electronic configuration of semiconductor surfaces has

been studied in the silicon-oxide interface and the cadmium sulfide surface. A tunneling spectroscopic technique applicable to metal-insulator-semiconductor systems has been used for the silicon-oxide interface. Cleaved surfaces of cadmium sulfide have been found to be essentially insensitive to light and to oxygen although preliminary results indicate that water vapor interacting with oxygen and light has substantial effects, bringing about changes in contact potential of 0.1 to 1 volt.

Work on semiconductor thin films has continued along three experimental approaches, sputtering, direct evaporation and vapor transport. Work on sputtering has concentrated on the preparation of cadmium sulfide films of improved crystalline and chemical perfection. An evaporation source has been designed to achieve steady deposition rates of around 100Å/sec. A number of methods have been examined for determination of the thickness of silicon carbide films deposited on single crystal silicon carbide substrates by vapor transport. The only successful method was based on employing substrates of different conduction type from the deposit.

Studies of amorphous semiconductor materials have concentrated on the arsenic selenide-antimony selenide system. Devitrification studies have been undertaken, since changes occurring during devitrification are important in attempting to understand the switching phenomena of such devices.

Work on semiconductor growth and characterization has included a study of the applicability of the Czochralski technique to the growth of gallium antimonide-indium antimonide single crystals. Only about 15 mol. per cent indium antimonide can be incorporated into the single crystal gallium antimonide matrix. Impurity heterogenities have been systematically revealed for the first time in germanium grown from the melt by the Czochralski technique. Excellent homogenization of crystals has been achieved under a sufficiently high rate of crucible rotation thereby suppressing the effects of thermal convection. An investigation into the growth and characterization of silicon single crystals is part of an effort to develop a growth system capable of pulling single crystals under zero gravity in outer space. Czochralski growth in transverse magnetic fields has also been studied with an indium antimonide melt. The effects of magnetic fields on growth characteristics in the absence of seed rotation are minor as long as only moderate thermal gradients are applied to the melt. However, irregular thermal conditions do seem to be frozen in by the magnetic field.

Severely deformed niobium-titanium superconductor wires have been fabricated from annealed rods by composite techniques. Critical field enhancement has been shown to occur but the practical use of such

techniques is probably limited due to other fabrication problems. This work was prompted by earlier studies of the critical field of severely deformed pure niobium. The effects observed in pure niobium are now rather well understood. A systematic search for optimal means of producing the compound Nb_3Al has been initiated and it is hoped to overcome the metallurgical problems which impede the use of this material, possibly the best high-temperature superconductor.

CERAMICS AND POLYMERS Professors H. K. Bowen, R. L. Coble, W. D. Kingery, D. R. Uhlmann, B. J. Wuensch. A reinvestigation of cation self-diffusion in unusually pure zinc oxide has been undertaken. Within experimental error, no anistropy of diffusion has been observed in these single crystals.

It has been shown that at 600°C or less the grain boundary diffusion mechanism operates in the sintering of silver in air. Grain boundary self-diffusion in lead is now being studied and the effect of pressure on grain boundary diffusion will be measured at pressures ranging from 1 atmosphere to 6 kilobars. The value of the boundary diffusivity seems to be about 4 orders of magnitude larger than the reported lattice diffusivity. Diffusion and defect studies have been continued on doped crystals of alumina. In titanium doped samples the coloration of the crystals as a function of the oxidation state can be used as an indication of the migration rate.

Studies of crystal chemistry have included the glass-forming sulfides, the bismuth sulfosalts, and the lead antimony sulfosalts. The structures of a number of such compounds have now been determined with some precision. Work on the thermophysical properties of wustite in a thermal gradient has now been completed. Only small concentration gradients result from thermal gradients. These studies will be continued on uranium dioxide since thermodynamic calculations predict a much greater fluctuation of composition with temperature in this compound.

Some success has been obtained in the growth of thin epitaxial single crystal films of $Y_3Fe_5O_{12}$ on nonmagnetic substrates by chemical vapor deposition techniques. The freeze-dry technique for the preparation of mixed oxides has been further developed. The process is presently being adapted to the preparation of mixed cerium, yttrium oxides although difficulty has been encountered because of the hygroscopic nature of the sulfates and nitrates of these salts.

The mechanism of inclusion damage in laser glass has been associated with the temperature rise of metallic particles relative to the surrounding glass. Melting conditions most suitable for the avoidance of inclusion particles in such glasses have been suggested.

It has been shown that the mechanism by which interconnected submicrostructures develop in many glasses is not necessarily by spinodal decomposition alone. In most cases nucleation and growth, followed by particle coalescence, could be viewed as a reasonable alternative to spinodal decomposition.

The crystallization of a number of polymers under high pressure has been shown to result in an extended-chain crystalline conformation, in contrast to the usual folded-chain conformation in polymers crystallized at normal pressures.

Studies on the formation of so-called polywater have led to simple methods for producing apparently anomalous water in sizable quantities. Standard silica gels are exposed to a laboratory atmosphere followed by heating the gels at elevated temperatures to drive off the water, collecting the water, and concentrating it to the desired extent.

STAFF

There have been four resignations from the Departmental faculty this year. Professor John F. Breedis resigned to accept a responsible position with AMF Industries, Professor David L. Holt resigned to accept a Senior Lectureship at the University of Auckland, and Professor Barry H. Rosof resigned to accept a post with the Stellite Division of Cabot Corporation. The fourth resignation will take effect during the summer; Professor Philip L. de Bruyn, a member of the faculty since 1949, has accepted a chair in chemistry at the University of Utrecht where he spent a sabbatical year in 1968. His important position as Graduate Registration Officer will be filled by Professor Kenneth C. Russell. The contributions of all four to teaching and research have been of enormous value to the Department and we acknowledge them with gratitude. The loss of four faculty members in one year implies a serious though, we hope, temporary loss of strength in the important areas of thermodynamics and electron microscopy.

Dr. Arden L. Bement, who spent the year as Visiting Professor of Nuclear Materials, has accepted appointment as Professor of Nuclear Materials jointly in this Department and the Department of Nuclear Engineering.

Professor Merton C. Flemings spent part of the year on sabbatical leave as a Fellow of Churchill College, Cambridge University. During his absence, Professor Harold Paxton, Head of the Department of Metallurgy and Materials Science at Carnegie-Mellon University, joined us for a one-term sabbatical during which he took over Professor Flemings' teaching in 3.141, Science of Materials. Professor Morris Cohen was appointed Chairman of the Committee on the Survey of Materials

Science and Engineering (COSMAT) which will undertake an 18 month study of the field of materials under the sponsorship of the National Science Foundation and including assistance from the Advanced Research Projects Agency of the U.S. Department of Defense. This new study, which is under the aegis of the Academy's Committee on Science and Public Policy (COSPUP) is the latest in a series of surveys of major disciplines that have included chemistry, mathematics, physics and the life sciences. Materials science and engineering has been selected as the first interdisciplinary field to be investigated because of several important examples successfully linking science and engineering for useful applications. Professor Cohen was also awarded the Chevenard Medal of the Societé Française de Metallurgie.

Professor Ludwig Thomas of the Technical University of Berlin spent the year as Visiting Associate Professor in the Department where he took part in many Departmental activities and conducted research in his own field of the physics of solids.

Mr. Anthony J. Zona, our artistically-minded welding technician was appointed Technical Instructor in recognition of his valuable contribution to 3.19, Techniques of Metal Sculpture.

Visitors to the Department included Professor Rajendra L. Banerjee from the University of Moncton, working with Professor Averbach, Dr. Mircea Fotino, Research Fellow at Harvard, working with Professor Ogilvie, Mr. Akira Fukuzawa from the National Research Institute of Metals in Japan, working with Professor Elliott, Dr. Tatsuya Koizumi from Furukawa Electric Company in Japan, Dr. Jacek Lagowski from Warsaw, and Dr. Gyorgy Motal from the Tungsram Co. in Hungary, all working with Professor Gatos, and Mr. Tetsuya Okuda from Kobe Steel, Japan, working with Professor Pelloux.

Dr. Alexandre Revcolevschi from the Centre de'Etudes de Chimie Metallurgique spent a year, as Research Associate, also working with Professor Pelloux.

Dr. Walter G. J. Putschar and Dr. Alan L. Schiller were appointed Visiting Lecturers in the Department where they contributed to the teaching of the new subject, 3.101J Biomedical Materials.

Professor Roy Kaplow, who has served on a number of Institute committees, has been elected Associate Chairman of the Faculty.

The Fall Colloquium Series, arranged by Professor King, dealt with a variety of topics but the general theme was that of applications rather than basic research. The Robert S. Williams Lectures were presented by Professor Morris Cohen who took as his topics, "Diffusion during Plastic Deformation" and "The Nucleation of Martensitic Transformations."

THOMAS B. KING

DEPARTMENT OF NUCLEAR ENGINEERING

The number of nuclear fission power plants adopted for electric generation in the United States and abroad increased substantially last year. This is mainly a consequence of the excellent performance and safety record of the plants of this type already in service and increased concern about combustion products from plants burning fossil fuels. The past year also saw a number of more advanced experiments on plasma confinement which improve prospects that nuclear fusion will some day also become a practical energy source for power generation. The principal activities of the Department of Nuclear Engineering are concerned with these two nuclear energy sources, fission and fusion.

In the fission power field, Professor Kent F. Hansen organized a new subject, Nuclear Fuel Management, which deals with the behavior of fuel in nuclear power reactors and means for predicting and optimizing fuel performance. Professor David D. Lanning presented a new subject, Nuclear Power Reactors, which described the principal reactor types used or proposed for electric power generation, and their advantages, disadvantages and development problems. In the fusion power field, Professor Lawrence M. Lidsky gave a new subject, Thermonuclear Reactor Design, which forecast the principal characteristics fusion power systems may have and delineated their as yet unsolved engineering problems. For students in both fields without prior knowledge of heat and power engineering, Professor Edward A. Mason organized a new subject, Engineering Principles for Nuclear Engineers, which provided an introduction to fluid flow, heat transfer, power cycle thermodynamics and engineering mechanics. Professor Neil E. Todreas has rearranged and expanded the Department's other subjects in nuclear reactor engineering. In a new subject Professor Elias P. Gyftopoulos presented a new formulation of the principles of quantum thermodynamics.

Although the Department's degree programs are all at the graduate level, contact is maintained with undergraduates in other departments through conduct of undergraduate seminars, participation in the Interdisciplinary Environmental Projects Laboratory, supervision of senior theses, offering three subjects for undergraduates and inauguration of five-year, combined Bachelor's and Master's degree programs with the Departments of Physics and Civil, Chemical, Electrical and Mechanical Engineering.

The Master's degree program provides education appropriate for graduates who are being employed in increasing number at the nuclear power plants now coming into operation. The program leading to the Nuclear Engineer degree involves about two years of graduate study and

is proving especially suitable for persons employed in designing or building nuclear power plants or managing their technical operation. Although opportunities for graduates with the doctor's degree in Nuclear Engineering have diminished somewhat, our graduates with this research-oriented education remain in demand in government, industry and universities where advanced experimental or analytical techniques are required for solution of nuclear engineering problems.

The five-megawatt M.I.T. Research Reactor, directed by Mr. Lincoln Clark, Jr., remains the Department's principal experimental facility for the fission field. Professors Lanning and James W. Gosnell and their students have completed engineering studies of modifications for the core of the reactor which would triple the useful neutron flux of the reactor without increase in power. Application has been made to the Atomic Energy Commission for a license amendment to modify the reactor. Modification will proceed if AEC approval is secured, and if the cost is determined to be within available funds. The helium refrigeration plant at the reactor is being used by Professor Lanning to provide very slow "cold" neutrons. Professor Sow-Hsin Chen has completed construction of a versatile triple-axis neutron spectrometer, which, with AEC support, is being used in a variety of experiments on the structure and molecular dynamics of materials. Professor Michael J. Driscoll and his students, also with AEC support, are using the reactor as a source of neutrons for studies on the performance of the blanket of a fast breeder reactor. Professors Gosnell, Norman C. Rasmussen and Gordon L. Brownell are using the reactor for activation analysis studies of industrial and biological materials and of environmental pollutants. Professor Brownell is conducting experiments at the reactor on irradiation of mice with neutrons to provide data needed for subsequent planned use of the reactor by staff of the Massachusetts General Hospital in experimental neutron capture therapy for human cancer patients. The Reactor is also used by other schools and other M.I.T. departments, especially Physics, Metallurgy, and Earth and Planetary Science.

With support from Combustion Engineering, Inc., Professor Allan F. Henry and his students are developing new computational methods for fission reactor analysis. With support from Commonwealth Edison Co., Professor Mason and his students are investigating management of fuel in nuclear reactors and optimization of operation of nuclear plants in a power generating network. Addition of these two industrially supported research projects to the government supported work of the Department is an encouraging development.

Professors Lidsky and Ronald A. Blanken and their students are participating with other M.I.T. departments in construction of ALCATOR, a

fusion plasma experiment which will use the facilities of the Francis Bitter National Magnet Laboratory to provide the highest magnetic field yet used for plasma confinement.

Student enrollment dropped last year to 115 from the former level of 125-130, reflecting the combined effect of the draft and somewhat reduced financial support for students. AEC support of students will continue to decline next year, as the phase-out of the AEC Fellowship program accelerates. In previous years, the Department has attracted 25 to 35 students awarded these Fellowships in national competition. Present indications are that there will be no fellowships by 1973. As a partial substitute, the AEC has awarded the Department eight traineeships. It is encouraging to report that the Department has two new privately funded fellowships. Northeast Utilities has established the Sherman R. Knapp Fellowship in Nuclear Power Engineering, named in honor of their retiring Chairman. Friends of the late Dr. Theos J. Thompson have established an endowment fund, the income from which is sufficient to permit award each year of a fellowship named in honor of Dr. Thompson.

The untimely death of Professor Thompson, who was serving as U.S. Atomic Energy Commissioner while on leave from M.I.T., is an irreplaceable loss to the nation and M.I.T. A member of the Nuclear Engineering faculty since 1955 and designer, builder and Director of the M.I.T. Reactor, Professor Thompson was responsible for much of the excellence of M.I.T.'s program in Nuclear Engineering.

Through resignations, the Department is losing the valued services of Professors Thomas O. Ziebold and N. Thomas Olson. Both men will be missed. Professor Ziebold initiated the Department's activities on nuclear materials and the effects of radiation on them. Professor Olson developed experimental techniques for investigating radiation effects.

The Department is fortunate that Dr. Arden L. Bement, who was serving as Visiting Professor while Dr. Ziebold was on leave, has accepted a permanent position as Professor of Nuclear Materials, with joint appointment in the Departments of Nuclear Engineering and Metallurgy and Materials Science. Previously, Dr. Bement was R&D Manager of Fuels and Materials at the Pacific Northwest Laboratories of Battelle Memorial Institute.

Among notable events in the Department, mention should be made of appointment of Professor Gyftopoulos as Ford Professor of Engineering, election of Professor Hansen as a Director of the American Nuclear Society, and the opportunity afforded Professor Blanken to spend six months at the Lebedev Institute in Moscow on a U.S.-U.S.S.R. program to exchange fusion research workers.

On July 1, 1971, Professor Manson Benedict retired as Department

Head, after providing leadership for the Department of Nuclear Engineering since it was formed in 1958. As Institute Professor, Dr. Benedict will continue to contribute to the Department's programs of research and instruction. In Professor Edward A. Mason, who has been a member of the Nuclear Engineering faculty since 1957, M.I.T. has an exceptionally well-qualified new Department Head.

MANSON BENEDICT

DEPARTMENT OF OCEAN ENGINEERING

As a result of the broadening scope of the Department during the past few years the name of the Department was changed from the Department of Naval Architecture and Marine Engineering to the Department of Ocean Engineering with the approval of the Executive Committee of the Corporation. The Department of Ocean Engineering will offer undergraduate and graduate degrees in Ocean Engineering as well as Naval Architecture and Marine Engineering and will operate the Pratt School of Naval Architecture and Marine Engineering as an integral part of the Department.

In the past few years the major thrust in the Department has been the development of the graduate program. The greatly-expanded graduate program is "shaking down." Substantial new efforts are still underway in power systems, marine transportation, and underwater acoustics.

The emphasis during the current year is on laying the foundation for a strong but flexible undergraduate program. This new initiative was possible because of the increase in the faculty, particularly the junior faculty, over the past three years, and is in response to the substantially increased interest in engineering directly related to the oceans on the part of undergraduate students.

THE UNDERGRADUATE EDUCATION PROGRAM

During the academic year 1970-71, the Department intensified its effort to develop a viable and exciting undergraduate program for the following three reasons:

1. To accommodate the interest of an increasing number of undergraduates in ocean-related subjects;
2. To supplement the present undergraduate oceanographic opportunities with an exciting program in ocean engineering opportunities; and
3. To provide a new source of input into the Department's graduate program which, in turn, would lead to further strengthening of this program.

The undergraduate offerings had to be reorganized and supplemented to provide a solid foundation and, at the same time, allow greater flexibility for the existing degrees in Naval Architecture and Marine Engineering as well as the undesignated degree. Additional subjects had to be introduced in order to be able to offer a strong and flexible curriculum leading to an undergraduate degree in ocean engineering, which the faculty approved and which will be announced in the catalog for the next academic year. This new program will meet the definite demand for such an education from our undergraduate students.

The above-mentioned flexibility in the undergraduate education was introduced by limiting the required subjects to the absolute minimum and allowing the students to plan their further education through planned electives in consultation with their faculty advisers. Such a scheme allows either a broad or a specialized education depending upon the student's definition of his goals.

THE GRADUATE EDUCATION PROGRAM

The major effort in the graduate program in the Department for the current year has been one of consolidation of the many subjects which were developed during the past few years. Substantial changes are, however, still underway in the following areas:

POWER SYSTEMS Based on the initiative of Professor Carmichael, a new subject, Thermal Power Systems, is being offered in the current spring term jointly by Professor Carmichael and Professor Rohsenow of the Department of Mechanical Engineering. It is concerned with concept designs of novel power devices involving turbo machinery and heat transfer equipment. The enrollment in this subject is 31 students.

A new subject offering is planned for the fall term in the field of ocean engineering power systems. The emphasis will be placed on possible applications and techniques for using power in the ocean, other than ship power and propulsion.

MARINE TRANSPORTATION Effort is being made to integrate subjects more closely in transportation engineering offered by this Department with those offered in the Department of Civil Engineering, the Department of Aeronautical and Astronautical Engineering, and the Operations Research Center.

Professor Devanney's research on "Marine Decision Making under Uncertainty," which is being supported under the M.I.T. Sea Grant Program, has substantially facilitated the development of this subject offering in this field. Particularly, he has concentrated on the treatment

of the ship charter market, but this background will also be a crucial input into the study of the development of marine resources, another subject which will be offered in the next academic year.

REVISION OF DOCTORAL EXAMINATIONS

The Doctoral Qualification Examination procedure has been changed markedly from a one-step to a two-step examination. The intent is to determine in the first examination the broad background in the engineering sciences, and in the second examination the background in depth relating to the general area in which the doctoral candidate intends to carry out his thesis. This permits a more meaningful evaluation procedure during this period of expansion for the Department. The Department expects a significant change in attitude toward the first-step examination. More students may attempt the first step since its prerequisites are at the somewhat lower level of educational development. However, the second step will be at least on the same level as the doctoral examinations conducted in the past.

PLANS FOR A SHIP DESIGN LABORATORY

The Department recognizes the urgent need to strengthen the teaching and research aspects of ship design. A step in this direction will also facilitate a broader attack on ocean engineering designs in the future. Particularly, emphasis must be given in this new approach to the great potential which computer applications offer. Plans for a Ship Design Laboratory are in the process of being formulated. The objectives of the Ship Design Laboratory are:

1. To facilitate and foster the effective teaching of ship design at M.I.T. and to evaluate the effectiveness of design instructions at M.I.T.;
2. To facilitate and foster theses and research related to ship design; and
3. To translate the results of ship research into design guidance.

It is hoped that support for the development of this laboratory can be obtained.

NAVAL ARCHITECTURE AND MARINE ENGINEERING

The present program is retaining a substantial interest among graduate students with 89 of the 121 graduate students in the Department in the process of obtaining a degree in naval architecture and marine engineering.

OCEAN ENGINEERING PROGRAM

The ocean engineering program is gaining increasing interest, particularly among applicants to the Graduate School. Of the present 121 graduate

students, 35 plan to obtain a degree in ocean engineering.

The Ocean Engineering Program includes the joint M.I.T./W.H.O.I. Ocean Engineering Degree Program which is tailored for those students wishing to specialize in that phase of ocean engineering which is needed to advance modern oceanography. At present there are two students in the second year of this joint program residing at W.H.O.I., and four students in the first year of the program presently residing at M.I.T.

This joint M.I.T./W.H.O.I. Ocean Engineering Degree Program leads to either the degree of Ocean Engineer or the Ph.D. degree in ocean engineering. This program is administered through a Joint Committee on Ocean Engineering, which is patterned after the joint M.I.T./W.H.O.I. Committee on Oceanography.

XIII-A PROGRAM

The "Dual Masters Program" now underway within XIII-A options on a pilot basis is creating great interest among students, the Naval Personnel Office, and at the Naval Postgraduate School, Monterey. This program is designed to permit a student to achieve two master's degrees, one in naval architecture and marine engineering and the other from the Sloan School in management in a concurrent three-year plan. The program recognizes the incompatibility for the average student of the course load and scheduling difficulties in fulfilling the requirements for both the Naval Engineer and the Master's in Management in a three-year period. Four Naval officers are in the pilot program, with the first two scheduled to complete in June, 1972. The three programs leading to both a Master's degree and an Engineer degree will be continued as the major program.

XIII-B PROGRAM

The total number of graduate students in the XIII-B Program is 5.

The XIII-B Program in Shipping and Shipbuilding Management requires major changes as the two areas of shipping management and ship production control and management refer to basically distinct disciplines. It is therefore felt that shipping management should increasingly incorporate transportation analysis and engineering subjects offered by various departments in the School of Engineering and a more related program of management subjects. Offerings in ship production analysis consist at this time only of a basic subject and a series of subjects in steel fabrication and welding. Preliminary discussions with the School of Management resulted in the potential formulation of a core program in production management and material flow.

RESEARCH

The research volume of the Department increased 36 per cent over the preceding year. It is interesting to note that funds representing contract extensions amounted to 31 per cent of the total research compared to 30 per cent for the preceding year. This continued shift toward more new research projects is most encouraging, especially if viewed in light of the difficulty of finding new sources of research funding. The increase in new projects is in part a result of the Department's diversification.

STUDENT ACTIVITIES AND AWARDS

A report examining the role and practices of the M.I.T. Corporation Visiting Committees is currently being prepared by James M. Patell and Michael F. Vetter, both graduate students in the Department of Ocean Engineering. The study is being performed as an input to President Howard Johnson as incoming Chairman of the Corporation. While the scope of the report is restricted to the M.I.T. School of Engineering, the report should provide suggestions for use by Corporation Visiting Committees throughout the Institute.

Students of the Department have continued the Friday Afternoon Tankard Seminar in the Student-Faculty Lounge that is intended to bring students and faculty together to unwind after a long week. Formal presentations are avoided in favor of discussions or movies covering a wide range of interests that prompt some lively conversation. Topics this year ranged from "how-to-design-a-rudder-mechanism-for-Professor-Devanney's-sailboat" to "A Structural Rag Bag" by Commander Douglas Faulkner, NCRC, to "The Mechanical Properties of Ice" by Ken Maser. Also held were discussions to determine what action students could take to increase the number of undergraduates in the Department.

The Department also takes pride in the traditional awards: The Brand Award, given annually by the Society of Naval Engineers to the member of the graduating class in Course XIII-A with the highest academic standing, was received by Lieutenant William M. Simpson, USCG; The American Bureau of Shipping Prize, which is awarded annually to the student with the highest scholastic achievement for the third and fourth years in either Course XIII or Course XIII-B, was received by Mr. Alan Jeffrey Brown; Naval Ship System Command Award, which was awarded for the first time this year is given to the U.S. Naval officer with the highest academic standing in Course XIII-A, was received by Lieutenant Commander Carl Owen Brady, USN; Department Letter of Commendation, was presented to Lieutenant Jorge D'Almeida, PN, in recognition of his outstanding scholastic achievement in Course XIII-A.

SEMINARS AND SYMPOSIA

In October, 1970, the Department hosted an I.L.O. Symposium entitled "Marine Propeller Design and Analysis." The symposium was chaired by Professor J. E. Kerwin and presentations were made by Professors Kerwin, Cummings, Milgram, Lewis, and Mr. Loukakis. The presentations covered were: Numerical Procedures for the Design of Moderately-Loaded Propellers; Large Hub Propeller Design; "Off-Design" Performance under Conditions of Partially-Separated Flow; Performance and Design of Heavily-Loaded Marine Propellers; Propeller Vibration Tests on Self-Propelled Models.

The Department organized a seminar series in both the fall and spring terms covering a broad range of ocean-related subjects. Each series consisted of approximately 14 lectures.

The Department conducted three special summer subjects in the summer of 1970: Materials for Ocean Engineering Structures; Ship Production Scheduling and Control by Network Methods; and Welding Engineering for Modern Structural Materials.

MARINE RESOURCES READING AND REFERENCE CENTER

The Departmental library has a new name and a new purpose. The Marine Resources Reading and Reference Center, while continuing to collect and maintain naval architecture and marine engineering-related books, journals and reports, will begin to delve into the fields of marine biology, marine geology, and fishing economics. The Reference Center will reflect in its collection reports of current studies funded by the M.I.T. Sea Grant Program. The Reference Center plans to accumulate information from a wide variety of sources and, in the future, may turn to microfiche and microfilm readers as space savers.

Presently 50 journals and 22 bulletins are received monthly. These are of interest to naval architects, marine economists, and ocean engineers. The Reference Center is also on the mailing lists of all Sea Grant Institutions and receives all related information.

THE FRANCIS RUSSELL HART NAUTICAL MUSEUM

During the Institute's first Independent Activities Period in January, 1971, the Curator of the Hart Nautical Museum stepped out of his usual occupation of "cleaning and oiling ship models" — one visitor's opinion of the job — and gave 14 hours of lectures on the history of ships. A total of eight persons attended at one time or another, but the average was four. It is interesting to note that in the Institute's catalog the History of the Automobile is offered as a 3-0-6 subject, while "American Shipbuilding — the Clipper Ship and the Ironclad," a phenomenal range of topics, is buried in the History of Technology in the United States. During

the year the curator gave his usual lecture for the freshman seminar conducted by Professor D. P. Adams and for the Munson Institute of American Maritime History at Mystic Seaport. Many school groups visited the museum with their own teachers.

Special exhibits in the Building 5 corridor cases this year included two that carried over from the previous academic year, one on structural models and the other on unsuccessful candidates for the defense of the *America's Cup*. The new exhibits have included the changes in tanker design, sailing freighter design from 1940 to 1960, the development of early American steamboats, and the use of catamarans since the seventeenth century.

The museum has acquired three models to fill gaps in its collections — the tanker *Narragansett* of 1903, a typical trading ketch of 1670, and an ocean-going tug of the World War II period. A finely-built model of the whaling bark *Wanderer* was received on deposit from the estate of Edith B. Holmes. Models now under construction include the steamship *Gloucester* of 1893, an Esso tanker of 1936, and fishing schooners of 1853 and 1889.

The year's conservation program saw the treatment of several valuable lithographs from the Forbes collection.

The museum and its fishing vessel collection were the subject of a featured article in *The National Fisherman* for April 1971 and a researcher from the *Bostonian* magazine has obtained material for future publication. The museum has furnished illustrations for several books and journals.

A major part of the curator's work involves answering a continual stream of telephone calls, letters, and visitors seeking information pertaining to yachts, fishing schooners, revenue cutters, clipper ships, models, paintings, and the like. The questioners have ranged from school children to a German rear admiral. The file of blueprints gathered in the past as teaching aids is proving to be a unique file on American shipbuilding during the late nineteenth and early twentieth centuries. As an example, this museum was able to furnish the Smithsonian Institution with copies of the only known plans of the first tank steamer built in the United States. It is gratifying to receive from visitors letters with such comments as "let me say that I consider your museum one of the most interesting I have visited," which came from a Californian.

FACULTY

In June 1970 Captain W. R. Porter, USN, joined the Department with an appointment as Professor of Naval Architecture, replacing Captain D. A. Horn, USN, Professor of Naval Construction, who retired.

At the same time Commander Warren C. Dietz, USN, joined the Department with an appointment as Associate Professor of Marine Engineering, replacing Captain S. C. Reed, USN, who was transferred to the Ship Concept Division of the Naval Ship Engineering Center.

The Department is pleased that the Institute promoted two faculty members, Professor Koichi Masubuchi from Associate Professor to Professor with tenure, and Professor John W. Devanney from Assistant Professor to Associate Professor.

Professor Patrick Leehey is on sabbatical leave during the 1970-71 academic year, carrying out research at the Max Planck Institut für Strömungsforschung in Göttingen, West Germany. He is expected to return to his regular teaching duties in the fall term, 1971-72.

Approval has been granted to Professor Abkowitz to take a sabbatical leave during the academic year 1971-72. He plans to accept an appointment of Visiting Professor at Ecole Nationale Superieure de Mechanique (University of Nantes) and at Ecole Nationale Superieure de Technique Advances (Paris).

VISITING SCHOLARS AND ENGINEERS

The Department was fortunate in having the services of the following visiting scholars and engineers: Mr. E. Dallwig, Visiting Engineer; CDR D. Faulkner, RCNC, Research Associate; Dr. F. Obermeier, Visiting Scientist; and Mr. G. Snyder, Visiting Engineer.

ALFRED A. H. KEIL

SCHOOL OF HUMANITIES AND SOCIAL SCIENCE

The past year brought to the School of Humanities and Social Science both a greater external calm and, in some quarters, a somewhat more intense internal ferment. As in the Institute as a whole and, indeed, most other educational institutions, the decline of political activism allowed both students and faculty to return to a renewed concentration on the more traditional forms of educational communication. Even the Center of International Studies, though still the target of a small group of vocal critics, had an essentially peaceful year because of the failure of its opponents to induce any appreciable resonance in the community as a whole. Our ferment, on the other hand, was the more welcome kind concerned with curricular and educational issues.

One of the most important events of the year was the approval of the formation of the Department of Philosophy, effective July 1, 1971. Since the establishment of the Ph.D. program in Philosophy in 1964, there had been a steadily strengthening eagerness for departmental status among the members of the Philosophy Section of the Department of Humanities. Although some opposition was encountered among the Faculty as a whole, a gratifying consensus emerged that the philosophers were indeed entitled to the departmental identity that they had long desired. To the extent that interdisciplinary cooperation is still needed in the manning of some of our general education subjects, it is hoped that the philosophers' participation will not be weakened by their new departmental independence.

It should be acknowledged that the spontaneous organization of the Department of Humanities some years ago into four Sections — History, Literature, Music, and Philosophy — has been followed by a fairly

steady increase in their degree of autonomy. As a result, the same aspiration for departmental status that has now been achieved in Philosophy is also growing among some of the other faculty, most strongly so in Music. On the other hand, sentiments are more divided in such areas as History and Literature, where there is more cross-disciplinary collaboration. The multidisciplinary department also has an advantage in facilitating the development of new programs of which the most promising is the one in Anthropology. The newly added sophomore option in that field is now to be supplemented with a set of intermediate subjects that will make it possible for students to specialize in that field as a part of their major in Humanities and Science (or Engineering).

Aspirations of a different sort have emerged in the Department of Foreign Literatures and Linguistics. It has been possible for some time for students to incorporate components of the department's offerings in an undergraduate major within the framework of the Department of Humanities' Course XXI. As Professor William F. Bottiglia indicates in his departmental report below, there is strong sentiment among his faculty for the authorization of an explicit undergraduate major under the department's own label and administration. This is supported within the School, and it is hoped that the implementation of this recommendation will not be regarded as too costly, despite the new financial stringencies.

The Departments of Economics and Political Science have been mainly concerned during the past year with proposals for curricular revision and administrative reorganization in their graduate programs. These programs have been notably successful in recent years — as Professors E. Cary Brown and Eugene B. Skolnikoff are able to testify in their reports below. In both departments, graduate students have urged that they be formally included in at least certain aspects of decision making having to do with the shape and content of the graduate educational programs. A limited amount of such participation has been welcomed by the faculty and the immediate results of the widened councils seem to be encouraging.

Deeper and more pervasive problems having to do with the role of humanities and social sciences at M.I.T. and in the Department of Humanities in particular have also come under rather intense discussion. To some extent these questions were opened up by the deliberations of the Commission on M.I.T. Education. Since that body was not able to provide unambiguous guidance toward the resolution of the questions posed, however, renewed and widened discussions have been initiated involving Professor Kenneth M. Hoffman as Chairman of the Commis-

sion, a group representing the Institute Administration, and a wide variety of faculty from various departments in the School of Humanities and Social Science but most especially the Department of Humanities. Since these discussions are still in an early stage, suffice it to say for the moment that they range broadly from a reconsideration of both the general structure and specific content of our General Institute Requirements in the humanities and social sciences to an inquiry into the causes and possible cures of some rather acute feelings of malaise on the part of some of our faculty as to their place in the Institute community.

REGISTRATION STATISTICS

The enrollment figures in Table I, in a form that has been standard for many years, show primarily the registrations in subjects acceptable for satisfying the General Institute Requirements in Humanities and Social Science. The table also includes certain other undergraduate registrations — from thesis to elementary and intermediate foreign languages. It does not include, however, certain undergraduate subjects, mostly in economics, that are offered primarily for majors and are not eligible for credit toward General Institute Requirements. Nor, of course, does Table I include enrollments in graduate subjects.

After many years of remarkably sustained growth, the "grand totals" in Table I reached a temporary peak in 1968–69 at 12,817, falling in 1969–70 to 12,318 and then recovering this past year to 12,844. The temporary dip of about 500 registrations was mostly accounted for by a decline of about 400 in the freshman and sophomore programs; the remainder was more than matched by a continuing decline in foreign languages. The registrations in the basic junior and senior elective program were essentially constant during the recession year and then resumed their advance during the year just completed. As for the fluctuation in freshman and sophomore registrations, this did not reflect changes in class size but rather an uneven pattern of postponing those requirements.

The principal innovations in the sophomore program were the additions of anthropology and music as optional fields. As compared with two years ago, when total registrations in the sophomore program were comparable, the approximately 650 registrations in the two new fields were matched by reductions of about 300 in history, 200 in philosophy, 100 in literature, and 50 in social science.

In our junior and senior program, prior to 1967-68 the four social science fields regularly drew slightly more registrations than the seven humanities fields (including foreign literatures and linguistics and

visual arts, as well as the five fields in the Department of Humanities). Since then, however, the social science enrollments have fallen off slightly, from 3,650 to 3,551, while the humanities registrations have continued to increase vigorously, from 3,810 to 4,763 — or from 51.1 per cent to 57.3 per cent.

The relative ranking of all 11 fields are shown in Table II, together with the history of those relationships for the last eight years. Psychology has strengthened its hold on first place, which it has held for some time largely because of the great popularity of Professor Hans-Lukas Teuber's introductory lectures. The new field of interdisciplinary subjects has suddenly shot into second place, with almost half of its total registrations coming from Professor Jerome Y. Lettvin's lectures on "Biological Bases of Perception and Knowledge." The other field with strong growth over the past several years is visual arts, now in fourth place.

Economics and political science have both suffered absolute as well as relative declines, especially in the past year. Literature has recovered in the past two years from declines in the two years before that; history suddenly declined last year after two years of strong increase. Philosophy has been losing ground for several years; music fell off just this past year, perhaps because students were entering the newly available sophomore subject instead. The field formerly designated as foreign literatures has been strengthened both by the addition of an undergraduate subject in linguistics and by the inclusion of advanced language subjects for which credit is now given toward the General Institute Requirements.

Table III shows the numbers of students majoring in the various departments of our School. Undergraduate majors, having increased steadily for nine years up to 1968-69, have since fallen off especially in the past year. It remains to be seen whether this is a temporary decline, or whether it was the peak of two years ago that was abnormal. The numbers of graduate students have also declined during the past year. This is an Institute-wide and nationwide phenomenon, related both to the condition of the academic job market and the availability of financial support.

Tables IV and V show how the undergraduate majors in the various Schools divide their choices among the various elective fields of the junior and senior program in Humanities and Social Science. There are only minor changes from the patterns of recent years. Students in the School of Architecture and Planning remain the strongest customers by far of visual arts; they have weakened somewhat their traditional relative preference for social sciences over the humanities. The same is also true of students in the Schools of Engineering and Management. Students in our School have increased somewhat their relative preference

for humanities, but a trend toward less humanities and more social sciences, visual arts, and foreign literatures and linguistics is detectable in the School of Science.

Table I Registration in Humanities, Languages, and Social Science Undergraduate Subjects 1970-71

		Fall		Spring
Freshman program		946[1]		935[1]
Sophomore program				
Literature	167		188[2]	
Philosophy	235		126	
History	199[3]		310	
Anthropology	148		123	
Music	212		169	
Social science	77		127	
		1,038		1,043
History	332		338	
Philosophy	263		114	
Literature	372		460	
Music	148		198	
Interdisciplinary	829		513	
Total humanities electives		**1,944**		**1,623**
Economics	562		577	
Political science	324		211	
Labor relations	64		81	
Psychology	639		1,093	
Total social science electives		**1,589**		**1,962**
Foreign literatures and linguistics[4]		119		189
Visual arts[5]		479		409
Thesis				
Economics	5		7	
Political science	6		6	
Course XXI	17	28	40	53
English composition		4		3
Senior seminar (XXI)		45		—
Science writing		3		8
Elementary and intermediate foreign languages		274		150
Grand total		**6,469**		**6,375**

[1] Includes registration in special humanities subjects in French (fall, 24; spring, 24).
[2] Includes registration in comparable subjects in French (spring, 13).
[3] Includes registration in comparable subjects in French (fall, 18).
[4] Exclusive of 424 registrants in elementary and intermediate languages (fall, 274; spring, 150), but includes registrants in advanced languages (fall, 21; spring, 21).
[5] Taught by faculty of the School of Architecture and Planning.

Table II Percentage Distribution of Junior and Senior Electives in Humanities, Foreign Literatures, and Social Science by Fields, 1963-1971*

	1970–71	1969–70	1968–69	1967–68	1966–67	1965–66	1964–65	1963–64
Psychology	20.8	19.6	19.5	19.0	18.1	16.6	20.2	21.4
Interdisciplinary subjects	16.1	8.8	11.2	7.8	5.2			
Economics	13.7	15.1	15 3	18.1	21.9	22.8	19.9	19.7
Visual Arts[1]	10.7	8.8	7.0	7.3	6.7	6.4	4.8	3.1
Literature	10.1	10.3	8.4	9.8	11.1	12.7	12.5	12.5
History	8.0	12.6	10.5	8.3	9.1	10.2	8.5	5.6
Political science	6.4	7.5	10.5	9.8	9.6	9.2	9.3	10.4
Philosophy	4.5	5.7	6.9	7.5	6.9	9.3	9.1	13.2
Music	4.2	7.0	6.4	7.1	7.2	7.7	8.9	8.2
For. Lit. & Linguistics	3.7	2.2	2.6	3.2	1.9	2.7	4.3	3.5
Labor relations	1.7	2.4	1.7	2.1	2.0	1.9	2.1	2.3

* Omitting registrations in the Freshman and Sophomore programs and in the miscellaneous fields following Visual Arts in Table I.
[1] Taught by the faculty of the School of Architecture and Planning.
[2] Exclusive of elementary and intermediate language subjects; includes advanced language subjects.

Table III Majors in the School of Humanities and Social Science.*

	Undergraduates				Graduates						
	Social Science		Humanities	**Total**	Social Science		Humanities	Foreign Literatures		**Total**	**Grand Total**
1955–56[1]	40		19	**59**	52		—	—		**52**	**111**
1956–57	38		32	**70**	69		—	—		**69**	**139**
1957–58	41		67	**108**	74		1[2]	—		**75**	**183**
1958–59[3]	46		75	**121**	81		1[2]	—		**82**	**203**
1959–60	38		64	**102**	105		2[2]	—		**107**	**209**
1960–61	35		93	**128**	114		—	—		**114**	**242**
1961–62[4]	55		88	**143**	129		—	7		**136**	**279**
1962–63[5]	65		85	**150**	145		—	22		**167**	**317**
1963–64	71		87	**158**	165		4	31		**200**	**358**
1964–65[6]	78		109	**187**	190		15	36		**241**	**428**
	Economics	Political Science			Economics	Political Science	Psychology	Philosophy	Linguistics		
1965–66	50	60	114	**224**	111	63	23	24	34	**255**	**489**
1966–67	76	73	121	**270**	117	79	26	29	42	**293**	**563**
1967–68	81	76	148	**305**	114	80	27	27	31	**279**	**584**
1968–69	84	79	195	**358**	118	87	27	23	38	**293**	**651**
1969–70	68	85	200	**353**	117	82	41	31	41	**312**	**665**
1970–71	60	59	162	**281**	103	78	23	36	34	**274**	**555**

* As registered in the second term of academic year 1955–56 to 1970–71 (omitting freshmen and undesignated sophomores).
[1] Course XXI initiated.
[2] Graduate degree in political science initiated.
[3] Special program in teacher training.
[4] Graduate degree in linguistics initiated.
[5] Graduate degree in psychology initiated.
[6] Graduate degree in philosophy initiated, with small preregistration in 1963–64.

Table IV Distribution of Registrants in Undergraduate Electives by Schools and Fields (by numbers), 1970–71.

School	Economics	Labor Relations	Political Science	Psychology	Subtotal in the Social Sciences	History	Literature	Music	Philosophy	Interdisciplinary Subjects	Visual Arts	Foreign Literatures and Linguistics	Subtotal in the Humanities	**Grand Total**
Architecture	61	2	33	68	164	19	47	8	13	67	313	5	472	**636**
Engineering	421	75	85	465	1,046	186	125	86	56	351	161	70	1,035	**2,081**
Humanities	117	23	217	104	461	203	281	65	144	215	82	58	1,048	**1,509**
Management	52	19	25	47	143	25	25	14	8	65	17	1	155	**298**
Science	204	19	71	515	809	162	231	119	124	416	154	87	1,293	**2,102**
Unclassified[1]	274	7	104	533	919	75	123	54	32	228	161	76	749	**1,668**
Total	**1.139**	**145**	**535**	**1,732**	**3,551**	**670**	**832**	**346**	**377**	**1,342**	**888**	**297**	**4,752**	**8,294**

[1] This includes all students who have not yet made Course designations, Wellesley students, and a few unclassified graduate students.

Table V Relative Distribution of Registrants in Undergraduate Electives by Broad Fields and by Schools insofar as they can be identified, 1970-71

School-Field	Visual Arts	Foreign Literatures and Linguistics	Other Humanities	Social Sciences
Architecture	.49	.01	.24	.26
Engineering	.08	.03	.39	.50
Humanities	.05	.04	.60	.31
Management	.06	.00	.46	.48
Science	.07	.04	.50	.39

ROBERT L. BISHOP

DEPARTMENT OF ECONOMICS

This year was much calmer in many respects from those the Department has experienced in the past, but it was indeed a memorable one for the recognition given to Professor Paul A. Samuelson, as first American recipient of the Alfred Nobel Memorial Award in Economic Science, which he received for his wide-ranging theoretical researches into the fundamentals of economic analysis. We feel a sense of exhilaration and pride at this honor to one who has given so much to his profession, university, students, colleagues, and the public.

A number of academic innovations were made this year, modest when considered singly, but which in the aggregate point toward a significant reshaping of the economics program.

TEACHING ACTIVITIES

The Independent Activities Period in January was an Institute innovation which, in general, was well received by the Faculty and student body. It made possible a number of discussions on current economic programs, mini-courses, reports on current research, and a student-organized discussion group.

The undergraduate program was continued essentially unchanged with minor modifications in existing offerings and the designation of the undergraduate econometrics subject, 14.31, as an eligible laboratory subject. Because of the interest shown, the Department plans to expand its offerings in the urban area and pollution next year. The Undergraduate Economics Association, with Fred Fruitman as President, continued its past activities of speakers, faculty-student get-togethers, and discussion meetings.

The graduate program was again rated at the top of its field by the

American Council on Education — tied for first place with Harvard University in the quality of its graduate faculty and ranked first in the effectiveness of its graduate program. There is, of course, room for improvement. A number of changes, which are either under discussion or already being instituted, are aimed at greater flexibility for the differing backgrounds, interests, and pace of the graduate student body. For example, several workshops have been established in particular fields which meet weekly to discuss the research progress of students, faculty, or visitors. It is particularly aimed toward more effective thesis supervision and acceleration of thesis progress.

Along with other schools and departments, we have felt sharp reductions in outside financial support for our graduate students. A substantial portion of domestic students had been supported by NSF and NDEA fellowships. Indeed, our department has typically led the country in the number of entering students who have won NSF fellowships and elected this department as their choice for study. In the coming year these cutbacks will be felt most keenly at the dissertation level. For the past several years only a third of such students have lacked fellowship aid, whereas next year nearly two-thirds will require some other means of support. The prospect is for still further curtailment, because sources outside the government have also been drying up. In anticipation of these developments the entering class and the size of our graduate student body has been reduced by about 20 per cent.

Despite this cutback in size, we have expanded the number of students admitted with disadvantaged backgrounds. One received his Ph.D. this year, and this year's and next year's entering graduate classes will have a 12 per cent representation. Special tutorial programs have been carried out for this group, both in the summer and throughout the year. We do not have enough experience as yet to make a judgment on the overall success of these activities.

The placement of our graduate students was slower this year than last, but it indicated essentially cautious hiring practices rather than an absence of jobs. All of our students who were seriously on the market have been placed in satisfactory positions: 11 in universities, 2 in colleges, and 6 in research positions, mostly governmental. This latter is substantially larger than numbers in the past.

Finally, we have taken an experimental step toward broadening representation at Department meetings. Elected graduate students will participate on an equal basis with faculty members in matters that do not involve solely undergraduate matters or identifiable individuals (such as in the case of review of a student performance or a faculty promotion). This change will expand the present size of these meetings by about a

third, but we anticipate an improvement in communication and decision making because of the responsible participation so far indicated.

RESEARCH ACTIVITIES

Research output has been maintained at a high level, and a dozen monographs and four or five times that many articles have reported on these results. In last year's report the areas and personnel participating were indicated in some detail. Interest and research in these fields is continuing at an impressive level, but changes in the research emphasis can be seen in the enhanced study of such pressing social problems as ecology and the urban areas.

For example, the Ford Urban Grant made possible a faculty research seminar that met regularly throughout the spring term to review existing research in urban economics and to develop improved approaches to the modelling of the urban sector. This seminar was led by Professor Jerome Rothenberg and participated in by a dozen other faculty members. As an outgrowth of this seminar research on a metropolitan model focused on land values is being carried forward primarily by Professors Rothenberg, Franklin M. Fisher, John R. Harris, and Robert F. Engle. It is expected that it will provide a focus and integration for other urban research that is also being carried on in the Department, such as on local government finance, crime, education, manpower, labor markets, and land use.

PERSONNEL CHANGES AND HONORS

Visiting faculty consisted of Professors Michael Bruno of Hebrew University, Frank H. Hahn of the London School of Economics, and James Mirrlees of Oxford University. Professor Daniel McFadden of the University of California, Berkeley, was here for the year and gave a series of lectures as a Guest of the Institute.

Associate Professor Michael J. Piore was on leave this year to serve on the Governor's Advisory Council of Puerto Rico. Professor Everett E. Hagen has become Director of the Center for International Studies.

Finally, Professor Franco Modigliani was elected Vice President of the American Economic Association, Professor Robert Solow was appointed Trustee of the Institute for Advanced Study, and Professor Samuelson was recipient of the Alfred Einstein Commemorative Award, the Medal of Honor of the University of Evansville, Illinois, and honorary doctorates from the University of New Hampshire, Seton Hall, and Williams College.

E. CARY BROWN

DEPARTMENT OF FOREIGN LITERATURES AND LINGUISTICS

GRADUATE PROGRAM IN LINGUISTICS

A half-decade ago the American Council on Education conducted a nationwide survey of graduate education and found that, both in quality of faculty and in effectiveness of program, M.I.T. was rated number one by fellow professionals. It is a pleasure to report that in another such survey made five years later our linguistics faculty and doctoral program have again been accorded top rank.

Professor Noam A. Chomsky was awarded an honorary doctorate of Humane Letters by Bard College in June 1971. He will be on leave next year, doing research on syntactic theory — more specifically, on the universal conditions that constrain the form and function of grammars.

A book by Professor Morris Halle, in collaboration with S. J. Keyser, concerning English stress in verse has just been published by Harper and Row. He is currently engaged in work on two topics, a basic study of general phonetics, and an extended investigation of the nature and history of accentology in the Slavic languages.

Professor G. Hubert Matthews is preparing a sketch of Hidatsa grammar and is also developing practical syllabic and alphabetic othographies for Eskimo, as well as materials for teaching the structure of Crow and Lakota to Indian children.

Professor Kenneth L. Hale is involved in a variety of research projects — the comparative syntax of Australian languages, the syntax and phonology of several American Indian languages, the relative clause in a number of Non-Indo-European languages, the ergative (with S. Anderson), and the role of linguistics in bilingual education programs in American Indian communities. He has been promoted to the rank of Professor.

Professor René P. V. Kiparsky is continuing his work on phonology, particularly on rule ordering and functional constraints, and on historical linguistics, specifically on Indo-European accentuation. In 1969 he did joint research on Sanskrit grammar with Professor Shivaram D. Joshi in India and is now preparing to publish the results. Dr. Joshi will be at M.I.T. next year as Visiting Professor of Linguistics.

Professor John R. Ross has been on leave this year, working at the Language Research Foundation in Cambridge on generative semantics and the theory of grammar.

Professor James W. Harris is continuing his research in phonological theory, Romance linguistics, and various topics in Spanish phonology and morphology.

Professor David M. Perlmutter is preparing a major work on Slovenian syntax and is also doing research on agreement in universal grammar. He is close to completing a paper on Equi-NP Deletion and related problems in English.

Catherine V. Chvany, recently promoted from Lecturer to Assistant Professor, teaches in our undergraduate program, but is a researcher in linguistics. Her area of concentration is Russian syntax. She expects to finish a full-length transformational study of Russian modal verbs in the fall of 1971 and is also preparing a monograph on problems of sentences with the verb *to be* in Russian and in universal grammar. She is co-founder, co-organizer, and secretary of the New England Linguistic Society, which held its first regional meeting in May 1970.

UNDERGRADUATE PROGRAM IN FOREIGN LANGUAGES AND LITERATURES

At the Fourth International Congress of Germanic Studies at Princeton University in August, 1970, Professor Martin Dyck served as chairman of *Sektion Linguistik und Philologie 1* and gave a paper propounding a new theory of comedy. This paper is now being elaborated into a full-length work. After completing it, he plans to return to his book on Schiller's poetry, language, and imagination, already well advanced, and to carry through another major project dealing with the applicability of mathematics to or in literary interpretation.

Two anthologies edited by Professor Krystyna Pomorska will soon be published by the M.I.T. Press. She is currently at work on an analysis of segmentation in narrative prose and on a book concerning the poetics of B. Pasternak.

The volume on Gérard de Nerval which Professor Robert E. Jones has been composing for the Twayne World Authors Series will be completed in the fall of 1971. He has been promoted to the rank of Professor.

An undergraduate subject in linguistics, Language and Its Structure, was introduced this year by Professor Harris and was taken by approximately 70 students. This enrollment attests the high degree of interest on our campus in the M.I.T. approach to linguistics and suggests the advisability of expanding our undergraduate offerings in this area.

Professor G. Eugene Nelson was deeply involved in this year's Independent Activities Period. In addition to conducting a seminar on Heinrich Böll's *Billard um halb zehn,* he set up and advised a German House and directed the production in German of Lessing's play, *Der Misogyn*. During the current academic year, he has supervised a German

Table at Ashdown House, and both he and Robert C. Channon have served as freshman advisers.

The Humanities in French program, now completing its eighteenth year, continues to attract some of the finest undergraduates at the Institute. The staffing of this program has been extremely difficult because teachers fluent in French and possessing the necessary cultural background are in very short supply. The present staff is undoubtedly the best that has ever handled this exciting and demanding sequence. In view of the fact that every fall we must turn away at least 20 students who are fully qualified, it is our hope that a way can be found to expand the program from one to two sections on both the freshman and the sophomore levels.

The Department's proposal for an undergraduate double major, involving a science or engineering specialty, plus a concentration in French or German or Russian literature, or Russian language and linguistics, is in the hands of the Academic Council. A number of students have written to the Administration urging approval of this new degree program. We hope that action will be taken on it in the fall of 1971.

The undergraduate teaching staff is eager, not only to gain approval of a Course XXIII major, but also to participate more fully in the humanities core program for freshmen and sophomores. Discussions on what concrete form such participation might take have been held with members of the Commission on M.I.T. Education and will continue with its follow-up task force next year. The Policy Committee of the Department of Humanities has been granting petitions to substitute for the standard sophomore alternatives combinations of third-term and fourth-term (i.e., intermediate and advanced) subjects in French or German or Russian. It would therefore seem wise to advertise these combinations in the catalogue as regular options.

WILLIAM F. BOTTIGLIA

DEPARTMENT OF HUMANITIES

For some years now the Department of Humanities has been organized into four sections, corresponding to the fields of history, literature, music, and philosophy. As time has gone on, this structure has become increasingly important in relation to Departmental administration. Appointments and recommendations for promotion and tenure typically originate in and are screened by the sections. Sections have taken on greater responsibilities for administration and supervision of the degree programs in Course XXI. The sections are also internally organized in

the manner of departments: each has its chairman, its committees on curricula, appointments, promotion and tenure, and so on. The Department has in short taken on some of the appearances of a School.

Increased sectional autonomy has undoubtedly contributed to, though it is by no means wholly responsible for, a diminished sense of common purpose within the Department. Whether this is permanent and whether, if it is, it will in the end be seen as a loss, there is at any rate a certain gain: a growing awareness of the need for serious re-examination of the nature of the humanities and of their role in an institute of science and engineering. Recognition of this need has manifested itself especially in expressions of concern over the freshman curriculum in humanities. As the options within the core program grow in number and variety, provision of a rationale becomes more difficult and problems of staffing are aggravated. Some members of the Department have come to be sceptical, on both practical and theoretical grounds, of the ideal of a limited number of interdisciplinary introductions to humanities for freshmen; they urge even greater variety and flexibility than now exists. Others, though unhappy with the present format, retain the conviction that a relatively unified freshman program is theoretically defensible and practically feasible. The debate over these matters that has begun this year will no doubt continue into next. Whatever its outcome, it will intensify concern with the goals of undergraduate education in the humanities; and this in itself is surely a good thing.

CURRICULUM

As usual there are changes to report in the program for freshmen. Two alternative versions of The Western Tradition will be introduced next year, under the direction of Professor Alvin C. Kibel. Each expands into a full year's subject the material currently offered in one term of The Western Tradition. Modes of Self-Definition, which grew out of the older Identity and Autobiography, will itself evolve into Self-Definition: Writing and Thinking, in which the discipline of writing will receive a greater emphasis. Conflict and Community in America will become Culture and Society in America, an examination of the evolution of technological society in America. The sequence of which the first term was Morality and Myth and the second Art and Apocalypse will be supplanted by a new entry, Three Major Texts: Plato, the Bible, Marx. Another new entry, Identity and Purpose in Black America, will focus attention on the historical analysis of issues arising from conflicts between the promises of American democracy and the hopes and needs of its black minority.

The sophomore program in history will undergo expansion with the

introduction for next year of three new subjects: The Dynamics of Imperialism; Rationalism and Radicalism: The Dilemma of Liberal Society; and Modern World History. Besides these the older subject, The Twentieth Century: Revolution and Totalitarianism will be retained. Instigated by the History Section, the introduction of these new subjects is intended to provide students with more choice and to facilitate more productive use of the special backgrounds and interests of staff members.

A major innovation within Course XXI is the addition of anthropology as an area of concentration. Although under the sponsorship of the Department of Humanities, the program will in fact be administered by an interdepartmental committee consisting of Professors Martin Diskin, Heather N. Lechtman, and Arthur Steinberg of Humanities and Professors Kenneth L. Hale and George H. Matthews of the Department of Foreign Literatures and Linguistics.

PERSONNEL

Professor Richard M. Douglas enjoyed a well-deserved sabbatical leave the second term of this year. In his absence Professor Richard L. Cartwright served as Acting Chairman.

Professor Roy Lamson was honored by being appointed Class of 1922 Professor. In addition to his duties as director of Course XXI, Professor Lamson served on the Pre-Medical Advisory Board and on the Joint Committee on the Wellesley-M.I.T. Exchange Program. He continues his research on the literary and diplomatic career of Sir Philip Sidney.

After five years as chairman of the History Section, Professor Bruce Mazlish asked to be relieved of that post and was succeeded at mid-year by Professor Robert E. MacMaster. Professor Mazlish, in cooperation with Professors Arthur D. Kaledin and David B. Ralston, continued to contribute to scholarly journals.

Professor Wayne O'Neil published numerous articles on a wide variety of topics including phonology, historical linguistics, and politics.

RICHARD L. CARTWRIGHT

HISTORY SECTION

Similar to the Institute at large and American higher education in general, the History Section was engaged throughout the year in intensive discussions of its identity, purposes, and aspirations. Considerable progress was made in attaining more specific and consensual definition of the Section's still basic program of research and teaching on the problem of the nature of modernity and the processes of modernization, both viewed in comparative and global perspective. The Section regards this task of

self-definition as both central to all its activities and in need of further, deeper discussion, which will be undertaken again in the fall of 1971.

This year the Section also undertook a thorough deliberation of its relationship to the Institute Committee on International Affairs. A lengthy document was presented to the Committee in May setting forth the Section's current definition of its program and style, its research directions, and its recommendations on the best use of funds allocated to it from the Ford Foundation. The Section's sense of its role in that Committee's Institute-wide effort of furthering the study of international affairs was emphasized. Specifically, it was recommended that this role be two-fold: research in the Section's innovative kind of comparative, global history and helping to ground the Committee's overall effort in undergraduate teaching.

The Ford seminars for this year were arranged around presentations by both members of our own staff and visiting professors. With great skill, Professor Robert E. Herzstein led a discussion of Nazism and the European idea; Professor Thomas H. D. Mahoney chaired a lively session on Edmund Burke; Professor Ernst Nolte of Marburg University was singularly informative on student movements in the German Federal Republic; and Professor Fernando Henriques of the University of Sussex opened new perspectives on race relations in the Caribbean.

The Ford Visiting Professor in Comparative History was Professor Henriques, who proved a most attractive and stimulating visitor. He is being invited as a visitor in History again in the fall of 1971, when he will again teach comparative racial history. The History-Political Science chair was filled by a visitor, Professor Ernst Nolte, for the first time this year. His subject on the Cold War and the German Federal Republic attracted great student interest. Apart from the Ford Visiting Professorship in Comparative History, which he had held in the previous year, Professor Amos Perlmutter was also present in the fall term, when he repeated his interesting and very topical subject in the history and politics of the Middle East. For the spring term of 1972 the History Section has invited Federico Mancini of the University of Bologna, Italy, to be Ford Visiting Professor in Comparative History. He will give a subject on European labor movements.

ROBERT E. MACMASTER

LITERATURE SECTION

For the most part, 1970-1971 has been a year of watching the cumulative effect of the previous years' work on the literature curriculum. Our electives and core subjects were well-received and well-attended so that next year will see only minor changes in the Section's present subject

offerings. One of these changes will be the necessary expansion of creative writing subjects to meet the demand for them.

Our moving toward establishing a graduate program in literary theory has been halted by the general decline in academic fortunes. Yet we continue to discuss the matter with some hope for the future. In that vein the Literature section was host to the annual fall meeting of the New England Regional College English Association. Its topic concerned the graduate study of literature.

Members of the section also took a very active part in the various experimental programs for M.I.T. undergraduates: E.S.G., U.S.S.P., Social Inquiry, and other interdisciplinary programs.

PERSONNEL

Members of the Literature section continue to publish and lecture so widely and to be so active in their professional associations and societies that it is impossible to detail the full set of their activities. The following, however, are worthy of special notice:

Albert R. Gurney Jr.'s play, *Scenes from American Life,* was produced in Buffalo and at M.I.T. by the Studio Arena Theatre Company of Buffalo and in New York by the Lincoln Center Repertory Theatre. The play was extremely well-received wherever it went.

Louis Kampf was elected President of the Modern Language Association of America.

Eugene Goodheart spent the year in France, supported by a Guggenheim fellowship and Alvin C. Kibel will spend the spring term next year at the Center for Advanced Study in the Humanities, Wesleyan University.

Paul Zweig, who will go to Queens College in the fall, published a volume of his poems during the year. An earlier book of his, *The Heresy of Self-Love,* was also reissued in the Harper Colophon paperback series.

WAYNE O'NEIL

MUSIC SECTION

This year saw the introduction of The Language of Music, 21.07, as an option in the sophomore core curriculum. Nearly 350 students took advantage of this opportunity. Approximately 120 additional students could not be accommodated because of faculty and space limitations.

The Glee Club, the Choral Society, the Orchestra, the Concert Band, the Jazz Concert Orchestra, and the Logarhythms gave a great many concerts on campus, as well as on various concert trips.

The Concert Band, under the direction of John Corley, continued to

present original works by contemporary composers, many of them commissioned by the Band. The Orchestra presented old and new music with outstanding soloists drawn from professional ranks as well as from the student body. The Jazz Band, directed by Herb Tomeroy, continued to win plaudits, including international attention during a trip to the Montreux Festival in Switzerland. The Glee Club, conducted by Klaus Liepmann, joined with Simmons and Wellesley Colleges in the presentation of master works of choral literature.

The Choral Society, conducted by Klaus Liepmann, appeared at the Brockton Art Center with a program of Fauré and Brahms compositions, accompanied by Professors John L. Buttrick and Robert S. Freeman, and ended its season in May with a program of Billings, Carissimi, Mozart and Brahms. There was an open rehearsal of the *Messiah* with members of the M.I.T. Symphony Orchestra and the M.I.T./Regis College Glee Clubs conducted by Klaus Liepmann.

The Humanities Concerts, directed and coordinated by Gregory Tucker, presented five outstanding American Chamber Music Organizations: The LaSalle String Quartet, The Aeolian Chamber Players, The Waverly Consort, The Fine Arts String Quartet (in the first performance of Milton Babbitt's *Third String Quartet*), and, "Music from Marlboro."

During the January Independent Activities Period, a great deal of musical activity took place through the initiation and under the guidance of Professors Buttrick and Freeman. A seminar was offered on the four-hand piano literature, and the Ninth Symphony of Beethoven was studied from the musical, literary, historic, and aesthetic point of view, drawing on various members of the Department of Humanities and ending with two "read-through" sessions of the Choral Finale by members of the M.I.T. Choral Society, the Glee Club, and the Symphony Orchestra under the direction of Professor Epstein.

The climax of the musical season took place in New York. Three concerts were given in honor of Dr. and Mrs. James R. Killian, Jr. The M.I.T. Glee Club together with the Chapel Choir of Douglass College, the Haydn Society Orchestra of New York, and prominent soloists presented, under the Direction of Klaus Liepmann, Haydn's *The Seasons*, in Lincoln Center's Alice Tully Hall on March 30. On April 19 the M.I.T. Symphony Orchestra appeared in Carnegie Hall with David Epstein conducting a work of his own, and works by Ravel and Perle. The second part of the concert program brought the Emperor Concerto with John Buttrick as soloist. Finally, on May 11, the M.I.T. Chamber Music Group presented music by three members of the music faculty: David M. Epstein, John Harbison, and Gregory Tucker. In addition, Professors Buttrick and Freeman presented Four-Hand music by Mozart

and together with the M.I.T. Choral Society Chamber Group the Brahms Liebeslieder Waltzes. The concerts were an outstanding success with public and press. The large audiences contained not only alumni and friends, but also a great number of young high school students. Said the *New York Times* May 13, 1971: "If the Massachusetts Institute of Technology wanted to alter its image with the three concerts it has given here this season, it has certainly succeeded."

KLAUS LIEPMANN

PHILOSOPHY SECTION

At its meeting of April 21, 1971, the Faculty of the Institute voted to recommend to the Corporation establishment of a new degree designation, Bachelor of Science in Philosophy. The recommendation carried with it implicit approval of departmental status for the Philosophy Section. The Corporation responded favorably at its meeting of June 4, thereby granting to the Section the autonomy it has so long sought.

The move from sectional to departmental status is best seen as an organizational change naturally consequent upon the professional orientation required for successful operation of a graduate program. It is distinctly not a change of educational focus or emphasis. The program leading to the degree of Bachelor of Science in Philosophy is substantially that now in effect for undergraduates who concentrate in philosophy within Course XXI-B (Program 2). Philosophy will continue to be available as an area of concentration for those in Courses XXI-A and XXI-B (Program 1). The new department will continue its heavy participation in the teaching of freshmen and sophomores and looks forward to working in close cooperation with the Department of Humanities in this connection. For the immediate future at least, no expansion of the graduate program is anticipated.

PERSONNEL

Professor Boruch A. Brody delivered the major paper at the third congress of the Israeli branch of the International Union for Logic, Methodology, and Philosophy of Science. Professor Huston C. Smith delivered an address in the Distinguished Lecture Series at the University of Oregon and received an honorary Doctor of Letters from Hobart and William Smith Colleges.

We regret to report the resignations of Professors Mark A. Levensky, Allen Graubard and Robert Bolton. Professor Levensky will assume the position of Dean of Humanities at New England College, Professor Graubard will pursue research and publication in education, and Mr. Bolton has accepted a position at Rutgers.

Dr. Ned J. Block will join us next year as Assistant Professor and Mr.

Richard W. Miller as Instructor. Their presence will strengthen our offerings in philosophy of mind and theory of knowledge.

RICHARD L. CARTWRIGHT

COURSE XXI
HUMANITIES AND ENGINEERING XXI-A
HUMANITIES AND SCIENCE XXI-B, PROGRAM 1
HUMANITIES AND SCIENCE XXI-B, PROGRAM 2

Enrollment in Course XXI in the spring term of 1970-71 was 185, compared to 228 in 1969-1970 at the same period, then the highest enrollment since its inception in 1955. The enrollment of second-degree candidates, 30 in 1969-1970, also a record high, dropped to 19. Within the humanities disciplines, literature has again been first choice, history second, philosophy third, and music fourth. The Program in Social Inquiry increased from one to six. Course XXI-B-2 has for the first time enrolled more students than the combined Course XXI-A, XXI-B-1 (102-83).

The following tables give a brief summary view of the numbers involved.

Course Enrollment by Classes, Spring 1971

	History	Literature	Music	Philosophy	Social Inquiry	Major Departure	Total
Seniors (91)							
XXI-A	1	3	3	1	1		31
XXI-B, 1	6	11	3	10			48
XXI-B, 2	17	22	5	4	2		10
						2	2
Juniors (67)							
XXI-A	5			1			6
XXI-B, 1	8	8	4	7	2		29
XXI-B, 2	8	15		7			30
						2	2
Sophomores (27)							
XXI-A		1					1
XXI-B, 1	2	2		1	1		6
XXI-B, 2	7	10	1	2			20
							185

Course Enrollment by Disciplines, Spring 1971

	History	Literature	Music	Philosophy	Social Inquiry	Major Departure	Total
XXI-A	6	4	3	2	2		17
XXI-B, 1	16	21	7	18	4		66
XXI-B, 2	32	47	6	13		4	102
							185

Students in Course XXI-A and XXI-B, Program 1, balancing curricula which require the continuation of engineering or science subjects along with a chosen field in the humanities, have for several years elected mathematics, physics, electrical engineering, and life sciences as their leading choices. Mathematics which held top position last year again is first; psychology, for seven years a program in XXI-B-1, is in second place. The fields chosen by third and fourth-year students are as follows:

Mathematics	16
Psychology	13
Electrical Engineering	11
Physics	11
Life Sciences	7
Chemistry	6
Geology	4
Aeronautical Engineering	3
Mechanical Engineering	3
Architecture	2
Industrial Management	1
Major Departures	4

The major departures are in education and humanities and science. The departures, carefully planned by students and faculty, could constitute groundwork for a program in education. With the establishment of an independent Department of Philosophy, Course XXI will phase out its concentration (XXI-B-2) in philosophy beginning with the class of 1972, but will continue to offer philosophy as a component of XXI-A and XXI-B-1.

The purpose of the Senior Humanities Seminar has been to bring the experience of humanities, science, and engineering together on important problems. This purpose was generally achieved in the first decade of Course XXI, but more recently, the Seminar has been devoted to education in humanities and science, problems of learning, and practical experience in classrooms of primary schools. This past year the Seminar was devoted to the Boston-Cambridge community and its cultural institutions and responsibilities, a major departure from its previous humanities-science base, and education.

Of the six Robert A. Boit prizes awarded this year, four were given to Course XXI students, David Rothenberg, '71; Barnard C. Black, '71; Glynis Lomon, '73; and Robert Scanlon, '71. Bruce Wheeler, '71, an outstanding athlete at M.I.T. throughout his varsity career, received a

scholarship for postgraduate study from the National Collegiate Athletic Association.

ROY LAMSON

DEPARTMENT OF POLITICAL SCIENCE

In common with the experiences of other departments at M.I.T. and most other universities across the country, the 1970-71 academic year provided a sharp change from the immediately preceding years. The mood and atmosphere in the Department demonstrated a "return" to a focus on scholarship and teaching with very much less distraction from the politically oriented activities of the recent past. Whatever the reason, and there are many possible hypotheses, the students and the faculty turned inward once again towards studies and research. Within the Department of Political Science, this change of mood did not preclude a willingness and interest in planning for future directions and the growth of the Department's activities; in fact, much of the faculty time was engaged this past year in consolidating the structural and other changes that had been arrived at last year, and in examining the many choices and decisions before the Department affecting its future direction.

At the beginning of the academic year, Robert C. Wood left the Chairmanship of the Department to assume the post of President of the University of Massachusetts. He has been succeeded by Professor Eugene B. Skolnikoff.

Notwithstanding the difficulties of the last several years, the Department has steadily enhanced its quality and national standing under the Chairmanship of Professor Skolnikoff, Professor Wood, and Professor Wood's predecessor, Professor Pool. The publication of the American Council on Education Report this past year emphasized the position of our Department in the political science discipline. The M.I.T. Department of Political Science was rated sixth in the nation in overall quality and third in the quality of its graduate program. This was an improvement over M.I.T.'s rating by the Council five years earlier, and, given the relatively brief history of M.I.T.'s Department, demonstrates its acceptance by the profession as one of the leading national departments.

The first and most important objective of the past year was to implement the many structural changes that had been agreed to by the Department the previous year and to provide a continuity of administration and leadership that would free the faculty, in particular, to pursue their regular responsibilities. This objective was achieved. The various committees of the Department, on which both students and faculty

serve, functioned smoothly. A general openness in the affairs of the Department was maintained, and major contributions were made by undergraduates and graduate students to the issues that had to be faced during the year. A constructive and generally harmonious atmosphere prevailed throughout the year, and communications among all elements of the Department were open and without rancor.

A second objective was to begin the planning and discussion necessary to chart the Department's future course. Many issues have been raised. The growing budgetary restraints are serious, especially with regard to the support of graduate students. This year the Department was still able to provide support in some measure for all of its entering graduate students, but, it seems quite clear that by next year there will be a serious problem, unless we are able to make up the difference with research assistant support. Research funds are in even shorter supply, but the Department is confident that it can raise adequate research money.

Budgetary restraints themselves are obviously important, but they should not dominate our planning for the future. Rather, there is a wide range of opportunities and responsibilities ahead, among which it is better to choose, rather than to be forced to restrict our activities. In particular, there are growing pressures on the Department from other parts of M.I.T., from the Federal government, and from the local community. To these must be added the somewhat diverse objectives of different members of the faculty, who would like to see the Department move in a variety of directions.

The pressures from other parts of M.I.T. are in many ways the most interesting, for they represent both a substantial shift in the direction of the Institute and the acceptance of the Department of Political Science at M.I.T. In many different departments it is possible to observe growing awareness of the importance of considering social and political implications of science and engineering in research and teaching. Increasingly, individuals from many different parts of M.I.T. approach the Department asking for participation in research and courses. Added to this is pressure from the Federal government to direct research in multidisciplinary directions, which also leads others at M.I.T. to include political science as an integral part of research projects and proposals.

Some of the interests expressed outside the Department conform very closely with the interests and objectives of members of the Department. Others are outside the Department's present capabilities or interests. The problem of how to respond, and whether and under what conditions to respond, is a difficult issue, complicated by necessarily limited resources. Fortunately, the pressures from outside the

Department are complemented in part by increasing interest within the Department in research and teaching related to physical science and engineering. Such projects that are generated will also involve closer cooperation with science and engineering colleagues.

Coupled with these opportunities for strengthening or moving into new areas are our own concerns as to the nature and extent of our undergraduate teaching program. Many in the Department believe that we should substantially expand our undergraduate curriculum, in particular that we make an attempt to reach undergraduates at an earlier point in their careers with courses dealing with the political and social implications of technology and with the problem of relating values to technological development.

These and other related issues dealing with the choices we must make for the future were discussed at length at a very successful meeting with the Department's Visiting Committee during the spring term. Obviously, no definitive resolution of these questions could be expected; in fact we are only at an early stage in understanding what the questions really are. However, much of the time during the next year will inevitably be devoted to exploring choices within the Department and with the new Administration at M.I.T. to develop plans for implementing whatever decisions are reached. It does not seem to be a matter of substantial faculty expansion in the Department to meet any new objectives agreed upon, for the present budgetary situation, if nothing else, would not allow it. There will have to be some migration of faculty interest to new areas, some of which is already occurring, as well as a plan for bringing others to the Department for research or related appointments.

Whatever the longer term changes may be, the Department during this past year did make very substantial progress in filling out some of its most pressing personnel and other needs. In particular, we were successful at last in bringing to M.I.T. a senior professor in the American politics field, Walter Dean Burnham of Washington University at St. Louis. He is one of the top people in the country in the field and will add enormously to the Department's and M.I.T.'s resources in this critical area.

We were also successful in identifying an extremely promising junior person in the Latin American field. Wayne Cornelius of Stanford will be joining the Department full-time in July, 1972, though his appointment will begin formally in this next academic year.

The Department also is engaged in an extensive search for faculty in the urban field, which is and will continue to be one of our major new fields of interest. The area of urban politics is especially critical because Professor Alan A. Altshuler is going on leave to assume the

post of State Secretary of Transportation, to which he has just been named by Governor Sargent. Focusing on the field of urban politics will be an immediate objective during the next academic year, and we are also hopeful that in our recruiting we can expand the representation of minority groups on the department's faculty.

We had the benefit during the past year of three visiting and part-time faculty in different areas. Mr. Edwin Diamond, formerly Senior Editor of *Newsweek,* joined the Department first as a Senior Fellow and later as a Lecturer. He offered a fascinating subject related to the communications media which proved to be very popular with undergraduates throughout the Institute. Mr. Edward J. Epstein joined the Department as a Visiting Assistant Professor to assist in staffing the introductory American government subject. However, his great interest and competence in analyzing the performance of the news media, in particular, has led us to invite him to continue to be associated with the Department on a one term per year basis as a Visiting Lecturer. The combined interests of Mr. Diamond and Mr. Epstein in communications, coupled with competence already in the Department and M.I.T. is prompting us to explore actively the possibility of an Institute-wide major effort related to communications.

Professor Ernst Nolte of Marburg University in Germany was at M.I.T. for the spring term on a joint History Section/Political Science Department Visiting Professorship. Professor Nolte is a unique scholar on fascism and on post-war politics.

Several part-time faculty have resigned. Professor Ernst Halperin, who has been teaching subjects on Latin America, will be leaving the Department. Professor Paul Kecskemeti is retiring and Professor Joan M. Nelson is moving to New York City. In addition, Mr. Thomas A. Lehrer has decided to retire from his role as resident mathematician in the Department, a most serious loss indeed. All four of the part-time visiting faculty have performed excellent service for M.I.T. students and they will be sorely missed.

During the year Professor Jackson A. Giddens resigned to assume a fellowship at the new Woodrow Wilson Center at the Smithsonian Institution in Washington.

It also bears mention that the Department was quite active with several seminars and other offerings during the January Independent Activities Period. Perhaps the most successful of all, and possibly among the most successful at M.I.T. as a whole, were two programs arranged by Professor Lincoln P. Bloomfield and Mr. Diamond, that involved students in field work. Professor Bloomfield took a group of students for several days of visits with key figures at the United Nations. Mr.

Diamond arranged for a group of M.I.T. undergraduates to be present at the offices of radio stations, magazines, and newspapers to observe the process of collecting and disseminating the news. Students reported enormous enthusiasm.

As usual, it was a busy and productive year for the faculty in terms of writing. Four members of the faculty produced six books, seven members of the faculty have written chapters in or edited 19 books, and articles by the faculty have appeared in 28 different professional journals, many of which received articles from several members of the faculty. In addition, members of the faculty consulted widely in many levels of government, although Federal agencies predominated. The faculty were also involved in professional society activities. Beyond membership in the most familiar, the American Political Science Association, several of the faculty hold senior posts in national or international societies. Examples are Daniel Lerner on the executive board of the World Association for Public Opinion Research; Harvey M. Sapolsky, Secretary of Section K (Economic and Social Sciences) of the American Association for the Advancement of Science; Lucian W. Pye, on the Board of Directors of the Council on Foreign Relations; Donald L. M. Blackmer, co-chairman of the Council for European Studies; and Eugene B. Skolnikoff, President and Chairman of the Board of a new national association, the Science and Public Policy Studies Group. In addition, eight members of the faculty are either editors or on the editorial boards of professional journals.

Several honors were received by the faculty. Eugene B. Skolnikoff was elected to the American Academy of Arts and Sciences, Willard R. Johnson was selected for the first A.C. Jordan Lecture, Roy E. Feldman received a Fulbright-Hays Research Fellowship, and Professor Bloomfield was elected to the Board of Directors of the United Nations Association.

Members of the faculty also participated actively in a wide range of M.I.T. faculty committees, as is their responsibility, but the character of the participation seems to be changing. In addition to service on the standing committees of the faculty, there is growing participation on *ad hoc* and informal committees that demonstrate a growing interaction between the Department faculty and their colleagues at M.I.T. as a whole.

EUGENE B. SKOLNIKOFF

DEPARTMENT OF PSYCHOLOGY

The year under review — the seventh since the founding of the M.I.T. Department of Psychology — has given us several surprises: only a year

ago, we thought that the response by our students to the Department's offerings had reached its peak, but this year's enrollment in psychology subjects, though all electives, rose further, to go for the first time beyond 1,800 students. Similarly, there were good reasons, here and elsewhere, for expecting a down-turn in departmental resources; yet, instead, we were able to move forward, largely due to the generous intervention of the Sloan Foundation, which guaranteed the development of our newly formulated five-year program in the neural sciences. This new program sponsors instruction and research in brain-behavior relationships, on the advanced undergraduate and early graduate levels, by preparing students for a combined Bachelor's and Master's Degree in Psychology and Brain Science.

At the same time, the Sloan Foundation grant has made it possible to expand our commitments to advanced research in the three areas to which the department has been dedicated since its founding: the work in neurobehavioral science (study of brain-behavior relationships), the experimental analysis of perception and learning, and the study of early development and psycholinguistics. We are drawing closer to a stage where these seemingly diverse areas can be mapped into each other, as they must, if we are to have a rational science of behavior and of man's mind. We believe that the science of behavior, in spite of all the efforts that have gone before, is something yet to be achieved, and this conviction of being at a beginning gives equal impetus to our teaching and our research. In fact, the most surprising feature of the year just past is that the faculty still feels no conflict between their roles as teachers and as investigators. The spirit of adding to a new field pervaded their teaching and their work in the laboratory, making each an extension of the other.

INSTRUCTION

As in the past, the teaching of a great many students was carried out by a faculty that numbered very few: the same 12 regular faculty members as in previous years, aided by six of their associates in research and by five part-time instructors, taught a total of 12 undergraduate and 14 graduate subjects. The enrollment trends can be seen from the following compilation:

Psychology: Enrollment Totals

	1968-69	1969-70	1970-71
Undergraduate subjects	1,336	1,534	1,664
Graduate subjects	119	236	216
	1,455	1,770	1,880

In looking at these figures, several points should be kept in mind: the 12 faculty members in the Department of Psychology actually represent less than 12 full-time people, since one, Professor Stephan L. Chorover, was on sabbatical leave for all of 1970-71, and two others, Professors Jerry A. Fodor and Mary C. Potter, served half-time, one of them being shared with Philosophy and the other with City Planning. Despite the general eagerness to teach, there were thus some physical strains.

It seems plain that if we intend to maintain the present level of instruction, quantitatively and qualitatively, we will have to add to our faculty, particularly as we move increasingly toward more individualized undergraduate instruction, in seminars and laboratories. Such additions to the faculty should now be easier because of the assignment of new laboratory and teaching space in Building E20, adjacent to the present Psychology quarters in E10. The full utilization of that building, however, will require that we obtain additional construction funds, since the building is presently nothing but a shell, though a most desirable one, covering 11,000 square feet of prime space for a department that in its seventh year is bursting at the seams.

A continuing demand for undergraduate instruction at intermediate and advanced levels appears likely, particularly in view of the large attendance in this year's introductory classes. For the first time, the introductory subject, Psychology and Brain Science, had a combined fall and spring enrollment of over 900 students. Professor Teuber taught his subject in weekly two-hour sessions every Thursday night in Compton Lecture Hall; weekly one-hour discussion sections (14 in the fall term, and 21 in the spring term) were guided by junior instructors and graduate students.

Such an attendance in the introductory subject tends to produce a surge in demand for intermediate and advanced-level instruction, and some of this surge is already discernible in the subjects that are approaching or exceeding enrollments of 100 students, Physiological Psychology, Psychology of Perception, Social Psychology, and Psychology of Language and Communication. An additional subject, Psychology of Learning, actually attracted over 200 students, and even such specialized topics as Origins of Behavior and Developmental Psychology were attended by about 50 undergraduates each. Evidently, the demand is there; the question is how to lead it into appropriate channels lest the Department be swamped.

One of these channels, as already indicated, is the new five-year program, leading to a combined S.B.-S.M. degree in Psychology and Brain Science. In the year just past, this program was duly reviewed and approved, and detailed descriptions of the program will appear in the

Institute catalogue for 1971-72. This degree program occupies the senior year and the first year in graduate school. Admission into the program is granted at the end of the junior year.

Although the program is carried primarily by the departmental faculty (it has been developed by Professor Richards, who continues to coordinate it), the program has also called upon the help of colleagues elsewhere at the Institute. Currently, Professor Jerome Y. Lettvin in Biology and Professor Richard J. Wurtman in Nutrition are sponsoring one student each under this new program, which for the time being should admit from four to eight students a year.

The individual students are being selected by the Departmental Committee on Graduate Admissions. After exposure to a common core, students in this program specialize in brain-behavior studies, the experimental analysis of perception and learning, or in the study of psycholinguistics and cognitive systems, including the use of mathematical models.

On the graduate level, the department continued its intensive doctoral training program for a group that comprised 24 students, thus keeping the student-to-faculty ratio at two to one. For the fall of 1971, we are admitting an additional five students, so that the number of doctoral candidates will increase to 29. We proceeded in this fashion, because we do not believe that the much-discussed over-supply of Ph.D.s, which seems to exist in certain fields, actually extends to those areas represented by our departmental training program. Nor have we seen any clear signs of increased difficulties in the placement of our graduates.

At the same time, the core program for the doctorate changed but little during the year under review. Much of the instruction, as befits a small graduate program, was carried in tutorials and seminars, and even more in joint work with instructors and research staff in the various departmental laboratories. One graduate subject, however, Professor Walle J. H. Nauta's justly famous Outline of Mammalian Neuroanatomy, did attract over 50 students last year, mostly through cross-registration from other M.I.T. departments and from other universities and medical schools within the Boston area. A subject was added in mathematical psychology and cybernetics, and the seminar in cognitive processes had a new instructor. The departmental colloquium program continued throughout both terms of 1970-71, with 52 guest speakers, of whom 13 came from abroad.

RESEARCH

The scope of work done in the departmental laboratories during the past year does not permit even the most cursory account in this report;

separate reports will be made available, together with the original papers and monographs that have been published by the departmental staff during the year. However, we should mention the increasing efforts in delineating connections in the nervous system, an analysis aided by special fluorescence techniques and, in the near future, the use of radio-labeled amino-acids. We should note, likewise, the attempts at further refinement in determining subtle behavioral effects after brain injury in man, and the investigations, in several departmental laboratories, of fundamental mechanisms of sight and smell, and of the acquisition and maintenance of skilled movements. New methods have been brought to bear on the overall problem of learning and on the incredibly swift and efficient ways in which normal children achieve distinctions among speech sounds they hear from the adults in their vicinity. The department's research programs were in the hands of a staff comprising the 12 faculty members, 10 research associates, 8 postdoctoral fellows, and the 24 graduate students. The work now in progress is a direct continuation of what began seven years ago, but considering the rudimentary state of our knowledge in these areas, we look upon the seven years past as a mere prologue for what is yet to come.

EPILOGUE

With all of these seemingly diverse commitments to teaching and research, one may well ask to what part of M.I.T. this seven-year-old department belongs. Is it logical to maintain the department within the School of Humanities and Social Science, or should it be transferred to the School of Science? Undoubtedly, the Department straddles these divisions, as do the fields which it represents.

It seems that the undergraduate response to our offerings derives to almost equal extents from their desire to understand themselves in relation to others and from an impulse to simply know more about man as part of the universe. Ultimately, these two questions merge into one: there are not two cultures, only different degrees of education. Yet, in the traditional view that separates the humanities from the sciences, psychology will always be the centaur without deciding which of its parts are more akin to man and which ones to beast.

Even within the sciences, our small department would continue to be somewhat of a sport, since its scientific program, though anchored in a single departmental frame, is exceedingly interdisciplinary, ranging from the investigations of brain mechanisms at molecular levels to the study of pattern perception, and thence to language acquisition by human infants. Undoubtedly, much of what goes on in teaching and research in M.I.T.'s Department of Psychology would be distributed over many

different departments and schools, if our program had grown up in a less unorthodox environment than that afforded by the Institute.

Yet, irrespective of its precise location within the administrative framework, the departmental program is probably better described as one in Psychology and Brain Science than in Psychology as such, since the program comprises not only psychological laboratories but also one of the most active neuroanatomy laboratories in this country, together with three neurophysiology units, a laboratory for the experimental analysis of early language learning, and a center for the study of changes in behavior after brain injury in man. The ongoing work in the more representative areas of psychology, from sensation and perception to learning and memory, can only gain from this simultaneous presence of the neural sciences, and psychological methods in turn are indispensable for posing the proper questions about what goes on in living organisms when they perceive or move, experience emotions, or remember. These fundamental questions are still so far from solution and yet so urgent that we should perhaps not be so surprised at the large number of students who want to enter this promising field.

HANS-LUKAS TEUBER

CENTER FOR INTERNATIONAL STUDIES

Under the directorship of Professor Everett E. Hagen the Center continued to conduct research in the areas of economic and political development, international communications, military and foreign policy, communism, revisionism, and revolution, and social science modeling and methodology. Several new projects were initiated by the Center this year.

STUDIES IN ECONOMIC AND POLITICAL DEVELOPMENT

Jose A. Silva Michelena's *The Illusion of Democracy in Dependent Nations,* the final volume of a three volume series, *The Politics of Change in Venezuela,* was published this year. This completes the Center's study of social and economic change in Venezuela. The final work of five studies on economic development in Chile done in collaboration with the Oficina de Planificacion Nacional of Chile will be completed in the summer of 1971.

Professor Myron Weiner was in India this year doing field research for his project on the social and political effects of internal migration in that country. Work proceeded on his study of Indian voting behavior being done here at the Center in collaboration with John Field. Professor

Robert I. Rotberg continued his study of African liberation movements. A new program of research was begun by Professor John R. Harris on Kenya. He is investigating the economic costs of instituting a program to divert industrial growth from a few urban centers of industrialization to a number of small cities.

Professor Lucian W. Pye's program of comparative research on Asian political cultures is proceeding with the final two studies expected to be completed in 1971.

STUDIES IN INTERNATIONAL COMMUNICATIONS

Professor Ithiel deSola Pool has continued his work on communication in the Communist world and developing countries. In collaboration with Dr. Zev Katz he has begun a project on the sociology of Soviet audiences, which will include studies of Soviet sociology, Soviet media research, an analysis of the 1970 Soviet census and computer simulations of the Soviet audience. Professor Harold R. Isaacs continued his work on ethnic identifications of white Americans, as part of his study of group identity and social change. Dr. Ai-li Chin is expected to publish the results of her investigation of identity patterns among American Chinese in 1971.

STUDIES IN MILITARY AND FOREIGN POLICY

Professor Lincoln P. Bloomfield and Amelia C. Leiss conducted several foreign policy and mediation simulations in Geneva and Vienna during the year as part of their studies of conflict within and between nations. Miss Leiss continued her work on models of arms races utilizing data from her earlier arms transfer project to develop an interactive and dynamic model of arms races.

Continued development of CASCON, a computer aided system for handling information on local conflict situations, was ensured by a collaborative arrangement with the University of Michigan.

Dr. Daniel Ellsberg's study of the process by which American foreign policy is formulated in periods of crisis is expected to be completed in 1972. Work proceeded on William P. Bundy's investigation of the events that led to the 1965 decision on Vietnam.

STUDIES ON COMMUNISM, REVISIONISM, AND REVOLUTION

Professor William E. Griffith completed a series of monographs on the Soviet-American confrontations as of 1970 as well as a study of the Cold War and co-existence among Russia, China, and the United States. Professor Donald L. M. Blackmer was in Italy doing field research for his study of left wing politics in Europe. Dr. Robin Remington was in

Yugoslavia and Poland as part of an exchange program which brought researchers from both of these countries to the Center. Professor Ernst Halperin is expected to complete his study of guerilla warfare in Latin America in 1971. The number of users of the project's extensive collection of documentary materials increased again this year, with a greater proportion of users from outside the Cambridge community. A number of manuscripts on particular issues are currently being done for the project by scholars not in residence at the Center.

STUDIES IN SOCIAL SCIENCE MODELING AND METHODOLOGY

Professor Hayward Alker in collaboration with Professor H. Douglas Price of Harvard University continued his work on modeling a variety of complex political systems. He is expected to complete the project in early 1972.

Stuart McIntosh and David Griffel with Professor Pool have begun development of MARK V ADMINS, a new generation of the Center's ADMINS data handling system. A new computer has been acquired and installation and initial testing of the system is proceeding. Research in computer languages for social science data handling has continued along with the development of an ADMINS language to implement the MARK V system. In addition, Professor Pool worked on the development of his general model of social science theory, an attempt to create an interactive conversational computer program to help social scientists in evaluating and developing social theory. Dr. Rosemarie Rogers has worked on two projects this year. The first is a study of how different ways of manipulating data affect substantive conclusions drawn from the data. The second is the design of a system of rules for identifying political themes in documents, to arrive at a computerized system of bibliographic search for a desired class of documents.

EVERETT E. HAGEN

ALFRED P. SLOAN SCHOOL OF MANAGEMENT

This report of the activities and accomplishments of the Sloan School of Management during the nineteenth year of its existence is in many respects like all the others. It is a record of continued effort and some considerable success in the evolution of effective programs for management education. Programs now exist which can contribute to the continuing development of men and women at virtually every stage of their career. It is a record of great activity and productivity in fields of research ranging from studies of the process of technological transfer to issues related to the effective delivery of health care, from questions of organization design to the development of improved analytical techniques. It is a record of extensive professional and public service activity wherein individuals from the School have participated and contributed to important developments around the world.

Despite the apparent similarity of these annual reports, the School's development has taken place in several phases, each of which has spanned a number of years. During the School's early years the activities of individuals within it were largely focused on the development of a new strategy for management education and research. This strategy involved the selection of faculty members from disciplines which had not previously been intimately involved with management education. It included the identification of important research questions on which these disciplines could shed new light. And it involved the development of a curriculum which would serve the needs of students whose careers would span the last half of the twentieth century.

The annual reports describing those years make it clear that there was both considerable optimism about these efforts and some uncertainty

about precisely how this strategy might be carried out. By the middle fifties, however, confidence in the strategy was clearly rising and attention was shifted to the development of new programs in which benefits of the new strategy could be made available to new kinds of students. In 1956 a program for senior executives was begun and in 1961 a doctoral program was undertaken. These additional commitments, each undertaken because specific needs and opportunities existed, demonstrated the growing confidence which the School felt in its basic strategy. The early sixties saw these programs successfully launched. The following few years recorded substantial activity devoted to their modification and improvement but by the middle sixties these programs were well established.

In 1966 both the obvious needs of society for improved management in non-industrial organizations and the belief that the School's competence could both contribute to and benefit from attention to these problems led to a decision to extend the School's commitments to include education and research in these domains. Recent reports have described these developments and this one records further progress in that direction.

This nineteen-year record of accomplishment is one to which all those who have worked or studied in the Sloan School over those years have contributed and of which they can be justifiably proud. It is perhaps appropriate now to turn to a more specific description of the past year's activities. At the end of this report I will comment briefly on my estimate of the tasks and opportunities which lie ahead for the Sloan School.

THE TEACHING PROGRAMS

THE UNDERGRADUATE PROGRAM

The present undergraduate program is now in its fifth year of operation. As in the past, there is general satisfaction with the program but specific changes continue to be made.

The program builds upon a small required core of subjects and a number of special option programs. The core consists of five basic subjects — Managerial Economics, Managerial Psychology, Managerial Environment, and Information and Decision Systems I and II. The Undergraduate Program Committee has continued to look for ways to reduce the number of required subjects in order to give the student more responsibility for his own education by affording him greater choice in its design.

Professors Paul R. Kleindorfer and Roy E. Welsch served as advisors for the Management Science option. This option continues to attract students interested in applying mathematics and computers to the prob-

lems of managing organizations. Professor Thomas J. Allen again served as the advisor for the Behavioral Science option. This program requires the student to study the social and behavioral sciences and their applicability to problems of management. The Dynamics of Management Systems option was headed by Professor John Henize. This option involves students in modeling of complex feedback processes using the methodology developed by Professor Jay W. Forrester. Professor Jay R. Galbraith continued to serve as the advisor for the special option. The special option is a popular one and is designed for the mature student who can take responsibility for his own curriculum design. It is the most flexible undergraduate option in the Institute.

Professor Myron S. Scholes served this year as advisor for the General Management option designed for the student who did not wish to specialize. Since this option has not attracted large numbers of students and is in principle available under the special option, the General Management option will not be offered after this year.

The number of double Bachelor's degrees granted by the Institute continues to increase. By far the most popular second degree continues to be Management. This year some 30 students will receive a second Bachelor's degree in Management.

THE MASTER'S PROGRAM

The Sloan School's two-year Master's program is designed to prepare young men and women to function effectively as professional managers in both private and public organizations.

Although the majority of Sloan School students in the past have aimed at careers in business and industry, there is now a rapidly growing interest in the management of other institutions of importance to society: hospitals, schools, cities, and government agencies. At the same time, there is an increasingly pressing need for better managers of all types of organizations. The basic approaches to problem solving and decision making developed for industry are applicable to non-industrial activities. The School encourages applications from those who seek careers in any of a wide range of enterprises.

In addition to opportunities to specialize in areas like marketing, finance, operations management, and management information planning and control systems, the School continues to stress the disciplines underlying the study of management — economics, behavioral science, and mathematics — as well as the analysis of complex, dynamic systems.

The Master's Program Committee has continued its efforts to increase student exposure to the broader problems of the relationship of managers with society. Each first-year student is required to choose one

elective which will satisfy this objective. Such electives as the American Legal System, International Business Environments, Studies in Public Operations Management, Private Industry and Environmental Problems, and Distribution of Income and Employment Opportunity are offered. Both first- and second-year students have elected one or more of these subjects in addition to the one taken to fulfill the requirement.

Membership in the Council for Opportunity in Graduate Management Education (COGME) has enabled the School to increase the number of minority students. Six of the nine black students in the Master's program have held COGME Fellowships this year. As COGME funds decrease during the next two years, substantial funds from other sources will be required if the increase in numbers of minority students is to continue.

The Master's Program Committee has, this year, begun to explore the problems and opportunities attendant upon the introduction of a 12- or 15-month degree program, and the Committee's task force plans to report its findings to the School's faculty in the fall.

THE DOCTORAL PROGRAM

The faculty of the Sloan School planned and adopted an entirely new Ph.D. program during 1968-69 which went into effect for the students entering in September, 1969.

The new program undertakes a shift in emphasis on the performance expected of the Ph.D. candidate. There is much more emphasis on research and teaching, and much less emphasis on grades and examinations in required subjects. It is expected that the candidate complete a major article-length research study before taking general examinations and his thesis. The new program also strongly recommends that each candidate teach in the Sloan School in "apprenticeship" with a senior faculty member.

There are no subject requirements in the new program; rather, the student is required to complete "part one examinations" in the discipline areas of economics, behavioral sciences, and applied mathematics, and "part two examinations" in major and minor fields of his choice. Part three consists of work done in relation to the thesis and "teaching apprenticeship." It is expected that all three parts will take no student more than three years to complete. Students with advanced preparation may complete the program in two years.

A review of the new program at the end of its second year indicates that almost all students are making the expected progress in examinations and in their research.

Sixteen Ph.D. degrees were awarded during the year.

THE ALFRED P. SLOAN FELLOWS PROGRAM

On June 4, 1971, 46 Sloan Fellows received the Master of Science degree in Management. This was the thirty-third class to complete the program and the twenty-seventh class whose members carried the designation of Alfred P. Sloan Fellows.

The composition of the class continues to reflect the growing interest of the non-industrial sector in the Sloan School. Three members of the class were medical doctors, representing the following organizations: The National Communicable Disease Center; Harvard University School of Public Health; and The King Edward VII Memorial Hospital (Bermuda). One member of the class represented the University of Hawaii and the management of the Peace Corps in the Far East.

Although the program continues to attract young managers primarily from commerce and industry (35 corporations), we welcome those executives who seek to improve the management of health services, cities, departments of the Federal government, and other public institutions. Students and faculty are both enriched by the opportunities to deal with a wide range of complex problems, and the School is pleased to contribute, when it can, to the solutions of problems in public as well as private systems and organizations.

The class of 1971 brought to M.I.T. some organizations that were represented for the first time in this unique program: Berenschot (Holland), British Petroleum (U.K.), Charmilles Corp. (Switzerland), National Institute of Economics (France), Honeywell, Harvard University, King Edward VII Memorial Hospital (Bermuda), Litton, National Communicable Disease Center, R. R. Donnelly & Sons, Shimizu Construction Co. (Japan), Torrington, and the University of Hawaii. We also welcomed back organizations that have not been represented recently in the program: Caterpillar Tractor and Dow Corning Corp.

In a number of different ways the program continued to stress the influence of the environment within which organizations operate. The importance of that dimension was reflected by the increasing number of formal and informal sessions dealing with the management of municipal and state government and with many of society's concerns today: pollution, equal opportunity, education, transportation, the war in Southeast Asia, and the impact of economic developments on industry. Theses topics also reflected the growing interest in contributing to the solution of environmental problems to which I have alluded in earlier reports.

The program continues to benefit from the able and devoted attention of Professor Charles A. Myers, Alfred P. Sloan Fellows Professor. As chairman of the Program Evaluation Committee, Professor Myers draws

the Sloan Fellows, their faculty, and administration into a continuing analysis of the program's content, emphasis, and objectives.

The Sloan Fellows Program continues to exhibit all the signs of vigor and growth. This year's class was selected from the largest number of applications in the program's history. The number of applications has been increasing steadily each year for several years. The quality of the applications is more and more impressive and the variety of backgrounds is richer every year.

THE M.I.T. PROGRAM FOR SENIOR EXECUTIVES

This year the Senior Executive Program Committee added a number of new important dimensions to this already successful program. The major areas of program content have been more effectively coordinated to the benefit of both faculty and participants. The introduction of a computerized management game has strengthened the management information and decision systems portion of the program and provided a stimulating, practical laboratory for the testing of concepts offered by the organization studies faculty.

The demand for places in the program is strong—particularly from executives of foreign corporations. For the last two years, the admissions policy has been to accept a larger number of applications from abroad. The participants from U.S. firms have welcomed the association with a wider variety of backgrounds and we plan to continue to accept a relatively large number of international managers in order to maintain a strong international dimension in the program.

Under the combined leadership of Professor Zenon S. Zannetos, chairman of the program committee, the other members of the committee, and the administrative direction of Mr. Joseph M. Patten, we have continued to extend the number of opportunities for participants to call upon and benefit from the School's resources while the program was in session. Participants have also reacted enthusiastically to the opportunity and the challenge of determining the content of the program to a larger extent than had heretofore been possible.

The design of innovative inputs to this exciting and demanding program is an ongoing process and there is every indication that improvements will continue to be made in what has for many years been one of the most effective programs of its kind.

THE M.I.T. PROGRAM FOR URBAN EXECUTIVES

The participants in the first three programs offered by M.I.T. have come from cities throughout the United States, Canada, and Puerto Rico. The

enthusiastic response of these men and women — and their sponsors — has been such that this program will continue to be a regularly scheduled offering. The fourth program is scheduled to run from June 20 to July 16, 1971. Applications have been coming in steadily and there is every promise for a fourth successful contribution to this important sector of society.

The roster of eligible participants has been broadened to include all levels of government below the Federal level: state and county as well as municipal managers. Typical titles of participants are: City Manager, Director of Housing Authority, Director of the Budget.

SUMMER PROGRAMS

In contrast with the nine Special Summer Programs offered during the previous year, 15 such programs were offered during the summer of 1970. The increase was primarily due to the expanded offerings in the management information systems area. The former single two-week program in this field was divided into six programs. Each was of one week's duration and all were offered within a four-week period. This provided the opportunity to combine individual programs into a number of different sequences. Professor David N. Ness coordinated the series and presented lectures in several of the programs.

RESEARCH IN THE SLOAN SCHOOL OF MANAGEMENT

The teaching programs just reviewed draw on much of the research done at the Sloan School. The development of new knowledge through research is basic to the maintenance of a position of leadership among graduate schools of management. While the major part of the research conducted during the past year has been primarily related to the private sector, it is encouraging to report that research in such areas as the effective management of education, health services, and urban systems continues to expand rapidly in the Sloan School. Graduate research assistants have been helpful in much of the research in the School, and Master's and doctoral theses continue to be an important element in the School's research strategy.

While it is impossible to describe briefly the full range and variety of the research program, it may be useful to comment briefly on the broad areas of research activity.

Research on human factors in management continues to be an important research domain. Projects ranging from attempts to understand

the career development of professionals, to work on better manpower models, to analyses of effective organizational design procedures, reflect the range but not the fine detail of work going on in this broad area.

The management of science and technology continues to be a special interest of faculty members in the Sloan School and research in this area is now being focused not only on transfers across organizational boundaries in domestic organizations but is increasingly concerned about international transfers of technology.

Research in industrial relations during the past year spread into a number of fields following the completion of a six-year study on the impact of computers on organizations and the nature of work. The role of the private sector in manpower development, labor relations and the particularly critical field of construction, as well as such social issues as labor distribution, unemployment, and labor relations in the public sector, once again reflect the range of individual research interests of faculty members in the field of industrial relations.

In economics and finance the pioneering work aimed at a better understanding of the capital markets available to private and public institutions continues to be an outstanding feature of the Sloan School and an extremely promising area for both student and faculty research. Studies of the effect of taxation on executive behaviour, the effects of regulation on corporate behaviour and economic analysis of the effects of education and the distribution of income represent additional themes in the School's economics and finance area.

The multinational corporation has attracted considerable attention from a number of faculty members and students. There is every reason to expect this set of interests will expand and deepen over the coming years.

Work on modeling the design of management information planning and control systems, operations management, marketing, and quantitative methods, long areas of great strength in the School, continue to yield fruitful research topics. These areas, studied in the past in the industrial context, are becoming promising areas of inquiry in the public domain.

Research on systems dynamics has now been extended by application both to urban and world policy issues.

In each of the topics I have named, and in many more which have not been mentioned here, research planning and direction continues to depend on the individual faculty member's imagination and energies. It is reassuring to note therefore that despite this strongly individual character of the various projects that the overall thrust of the School's research program continues to be directed at the important issues which our society can expect to face over the coming years.

INTERNATIONAL PROGRAMS

Increasingly, the School's concern with the international dimension of management is focusing on curriculum development, informal faculty collaboration, and research. Nonetheless, the School continues to be involved actively in two institution-building activities outside the continental United States—the Brazilian Development Banking Project and the Puerto Rican Public Management Project.

In the international management field within the School, a Sloan-initiated program for engaging graduate students of international management in studies for local firms of specific overseas markets for their respective products continues. In fact, due to the success of the expanded program last year under the title Program of Academic/Business Cooperation for Export Development, it has been expanded nationally under the sponsorship of the U.S. Department of Commerce's Bureau of International Commerce. The inclusion of schools in the program, combining their efforts with those of business and government, is expected to aid in expanding the export sales of small American companies, as well as provide valuable educational experience for the students.

LONDON GRADUATE SCHOOL OF BUSINESS STUDIES

In mid-1966, the Alfred P. Sloan Foundation made a grant to the new London Graduate School of Business Studies (L.G.S.B.S.) and to the Sloan School to launch an executive development program in the United Kingdom. Since then, a version of the Sloan Fellows Program has been instituted and the second group of young British executives has graduated as London Sloan Fellows after a year of intensive study.

The second form of cooperation with the L.G.S.B.S. has taken the form of a series of exchanges in residence by faculty members. These exchanges have continued to build effective bridges between the two schools and extend the good feelings and cooperative personal relationships which have marked the ongoing contact between the schools.

BRAZILIAN DEVELOPMENT BANKING PROJECT

In 1967, in pursuit of its interest in forwarding management education on a broad front, the Sloan School undertook the Brazilian Development Banking Project with the support of a Ford Foundation grant. The purpose of this cooperative effort with Brazil's National Bank for Economic Development (B.N.D.E.) was to transfer basic management technology to a developing country. It was hoped that such a strategy would improve the human and institutional resources of Brazil's 20-bank finance system and the hundreds of projects to which it has made loans.

The initial "field-work" stage of the program ended early in the year and Professor George F. Farris and Dr. D. Anthony Butterfield, aided by two Sloan School research assistants, are analyzing the preliminary results and evaluating the changes to determine the impact of the project. A research project designed to provide better understanding of the process of this type of technical assistance is in process.

The basic courses for Brazilian development bankers, which are designed to improve their managerial, appraisal, and control capabilities, have been institutionalized as they are currently being run by the B.N.D.E. system itself. The courses utilize a variety of material developed by the members of the project's team.

As a result of this project, two new possible areas of further endeavor have appeared: (1) to develop a new system of management education which would be more relevant for managers of small firms; and (2) to create the capacity in Brazil to do organizational research and development activities after further researching the effective management of Brazilian organizations.

SLOAN SCHOOL PUERTO RICO PROJECT

In 1969, Dr. Chandler H. Stevens went to Puerto Rico, on leave, to become a member of Governor Ferré's staff and took part in the formation of the Governor's Advisory Council for the Development of Government Programs. With the aid of many M.I.T. professors, the Council has conducted studies on economic, social, management, and environmental problems.

Professor Michael J. Piore of the Department of Economics replaced Dr. Stevens as Research Coordinator of the Advisory Council in June, 1970. Professor Edwin Kuh continued to provide liaison at M.I.T. with the Advisory Council, and Dr. Stevens remained Governor Ferré's Science Advisor and representative on the Governor's Council on Science and Technology in Society.

The citizen feedback system, designed by Professor John D. C. Little, Dr. Stevens, and a research team, is in operation to handle inquiries, requests, complaints, suggestions, and opinions directed from Puerto Rico's citizens to the Governor. As a result of this project, a similar system is being designed for the Governor of Massachusetts under a grant by the National Science Foundation.

THE FUTURE

As I indicated in my introduction to this report, the Sloan School has been the scene of considerable activity and substantial accomplishment

over the past year. As a result of my knowledge of and confidence in the individuals who work within it, I fully expect the School will continue to be that kind of organization. I do sense, however, some important external pressures with which this organization will need to cope over the years ahead. They will inevitably take the form of specific tasks undertaken by specific people but the organization as a whole will need to respond to these pressures if it is to continue to take full advantage of its opportunities and responsibilities.

Perhaps the most pressing challenge which the School faces is that of increasing its productivity. This term, always difficult to define in detail, has to do with the whole spectrum of issues ranging from costs and revenues to the effective utilization of resources including the time and talent of faculty, students, and administration. It may ultimately include consideration of appropriate involvement of the School in activities beyond those in which it is now involved both inside and outside the Institute.

During this year I asked a faculty committee to consider the School's tuition policy with respect to its regular graduate program. The committee recommended that the tuition in the regular graduate program be increased but its recommendation went considerably beyond this. The committee suggested that there existed a real opportunity to develop a graduate program which might be more effective for a certain group of students than the one which we have been offering for the past twenty years. More specifically, they suggested the development of an accelerated graduate program which would permit qualified students to take advantage of recent curricular developments and thus reduce the time necessary to earn a master's degree. After extensive discussion we have decided to pursue this idea and are in the process of making further investments in curriculum development. For the time being at least we will maintain our policy of charging regular graduate students the same tuition as that charged to all graduate and undergraduate students at M.I.T.

If this new program is successful, it will obviously be only the beginning step in a continuing analysis of ways in which our educational purposes can be effectively accomplished. It is becoming increasingly clear that means ranging from television, to programmed instructions, to carefully designed field experience are educational alternatives we should be considering along with the ancient questions regarding the range of pedagogical techniques which can be employed in classrooms. The whole issue of case method vs. other means of delivering the conceptual material now seems clearly to be out-of-date. Our educational purposes should be accomplished by the most effective means available

and the alternatives we must actively consider, and to some degree develop, are broader now than they have ever been.

Ultimately these developments may lead to substantial changes in organization. If carefully managed, however, I believe they can make our educational program not only more satisfactory and effective for the students but also for the faculty and all the others who will be called upon to contribute to the educational process.

Many of these changes will be stimulated by the interest and imagination of people within the School and the Institute. Some of these changes, however, will be encouraged by events outside the normal academic community. Corporations are increasingly concerned about executive development and are undertaking new programs to accomplish what they see as their objectives in this area. We have been pleased over the past few years that despite these developments many organizations continue to rely on university programs to play a part in their overall development plan. It is clear, however, that the Sloan School will need to continually evaluate its comparative advantage in the larger process of executive development and to continue to play a vital and valuable role in those efforts. Clearly neither the Sloan School nor universities in general are the only participants in this rapidly developing field and we will need to be increasingly aware of external developments in our continuing evolution.

In attempting to remain among those at the forefront of management research and education, new strategies will be required but I suspect some basic old ones will remain valid. I am sure the Sloan School will remain committed to the selection and development of individuals for faculty, students, staff and administration of the highest quality and given our continued ability to attract these individuals I am sure future reports of their accomplishments will serve to increase the pride of all those who have preceded them in the School's development.

WILLIAM F. POUNDS

SCHOOL OF SCIENCE

This year the Departments of Mathematics, Physics, and Chemistry offered a number of new options to freshmen to satisfy their science requirements. In mathematics, Professor Arthur P. Mattuck offered calculus subjects at several different rates so that students able to pass benchmark examinations could progress more rapidly; calculus subjects were also available during the January Independent Activities Period. Because of these changes and because of the better mathematics preparation many M.I.T. students now receive in high school, 40 per cent of the freshmen had completed their calculus requirement by the beginning of the second term. An applied mathematics version of calculus was offered by Professors Harvey P. Greenspan and David J. Benney. In freshman physics Professor George B. Benedek offered a new subject which utilized biological and medical examples, and Professor Earle L. Lomon offered the regular physics material in a seminar-tutorial mode rather than in the usual lecture-seminar mode. During the fall Physics, 8.01x, and 8.04x and during the spring Physics, 8.02x, 8.03x, 8.04x, and 8.05x were offered in self-paced study modes. Chemistry, 5.41 was also offered in self-paced study.

There were rather large increases in freshman enrollments in some of the subjects which have recently been made options for satisfying the science requirement: the enrollment in General Biology, 7.01, offered by Professors Salvador E. Luria and Paul R. Gross increased from 236 in 1969-1970 to 336 in 1970-1971; and the freshman enrollment in Chemistry, 5.41, offered by Professor Glenn A. Berchtold increased from 268 to 343. Further modification of freshman subjects, but not an increase in the number of options, is planned for 1971-1972.

The number of undergraduate majors in the School of Science increased from 970 in the fall of 1969 to 1,050 in the fall of 1970, while the number of graduate students decreased from 1,046 to 973. This decrease can be attributed largely to a reduction in funds available for the support of graduate students. Although the D.S.R. volume in the School of Science in fiscal year 1971 was almost exactly equal to that in fiscal year 1970, inflation has reduced the amount of research that can be done with these dollars. The number of postdoctoral positions was essentially the same in the fall of 1970 (257) as in the fall of 1969 (254). The numbers of postdoctorals in various departments are as follows: Biology — 72, Chemistry — 52, Earth and Planetary Sciences — 13, Mathematics — 12, Meteorology — 6, Nutrition and Food Science — 10, and Physics — 92.

George R. Wallace, Jr. of Fitchburg, Massachusetts, gave the Institute $300,000 for the establishment of an Astrophysical Observatory in the vicinity of Westford, Massachusetts, near the Haystack Radio Telescope. The Observatory was constructed during the year and has been equipped with a 24-inch reflector for research and testing photometric equipment and a 16-inch reflector in a separate dome for instruction. The facility will be known as the George R. Wallace, Jr., Astrophysical Observatory. Professor Thomas B. McCord has been appointed Director. The Observatory will add to the already strong programs in X-ray, radio, and radar astronomy carried out by faculty members in the Departments of Physics, Earth and Planetary Sciences, and Electrical Engineering.

The School of Science will begin the 1971-72 year with two new department heads: Professor Glenn A. Berchtold will succeed Professor John Ross, who was Head of the Department of Chemistry from 1966 to 1971, and Professor Kenneth M. Hoffman will succeed Professor Norman Levinson, who was Head of the Department of Mathematics from 1968 to 1971.

Professor Norman Levinson was named Institute Professor, Professor Frank Press was named Robert R. Shrock Professor of Earth and Planetary Sciences, Professor Isadore M. Singer was named Norbert Wiener Professor of Mathematics, Professor John Ross was named Frederick G. Keyes Professor of Chemistry, and Professor George H. Büchi was named Camille Dreyfus Professor of Chemistry. Two new faculty members were appointed Professors: Professor Alberto Calderon from the University of Chicago was appointed by the Department of Mathematics, and Professor Gordon Pettengill, who had been associated with the Lincoln Laboratory and who was serving as Director of the Arecibo Ionospheric Observatory, was appointed by the Department of Earth and Planetary Sciences. Two faculty members retired: Professor E. Lee

Gamble in the Department of Chemistry had been a member of the faculty since 1937 and Professor John T. R. Nickerson in the Department of Nutrition and Food Science had been a member of the faculty since 1952.

Members of the School of Science received many honors during the year. Professors William F. Brace of Earth and Planetary Sciences, Irving M. London of Biology, and Director of the Harvard-M.I.T. Program in Health Sciences and Technology, Professor Philip Morrison of Physics, and Nevin S. Scrimshaw of Nutrition and Food Science became members of the National Academy of Sciences.

ROBERT A. ALBERTY

DEPARTMENT OF BIOLOGY

During the year, 206 undergraduate students concentrated in the life sciences and 60 were awarded the S.B. degree in this field. There were 98 graduate students, largely candidates for the Ph.D. degree. Between July 1, 1970, and June 30, 1971, 13 Ph.D. degrees and seven S.M. degrees were awarded in biology. These figures show that the number of graduate students has remained approximately the same, but that the number of undergraduate students has increased by 44 per cent in a single year. This increase is also reflected in the number of S.B. degrees awarded. The number increased by 36 per cent during the last year. Judging from the number of freshmen who have indicated an interest in life sciences, it is estimated that the population of undergraduate majors in life sciences will exceed 300 in the course of the academic year. The interest of undergraduate students in the life sciences manifests itself also by greatly increased enrollment in subjects such as 7.01, 7.05, and the introductory laboratory, 7.011. Although the Department will be able to cope with increased enrollment in the lecture courses (for example, by offering 7.01 both terms beginning in the academic year 1971-72), its facilities are strained by attempting to provide the carefully planned and sophisticated laboratory instruction in 7.011 to the increasing number of students who wish to avail themselves of this instruction.

In the summers of 1970 and 1971, the Department obtained an NSF grant for research by undergraduate students. Fifteen students were supported by this grant during the 1970 summer and 21 were supported in 1971. Approximately 15 undergraduates were engaged in research during the academic year.

A very successful innovation was a brief course in electron microscopy

offered by Professor Jonathan A. King to undergraduate students in January.

CURRICULUM

After the rather extensive changes in curriculum reported last year, no major alterations have occurred in the undergraduate program in life sciences, however the Department has begun to offer several new subjects for graduate students and advanced undergraduate students. One of these subjects, offered by Professor Harvey F. Lodish, is Molecular Biology. Others deal with various aspects of the mammalian cell.

RESEARCH

The research by members of the Department's faculty, research associates, research fellows, and graduate students is described in a publication entitled *Research Summaries,* available at Departmental Headquarters. There has been great interest in this country and abroad in the exciting discoveries of Professor David Baltimore concerning the role of the RNA of a tumor virus as template for the formation of DNA.

PERSONNEL

Professor Luria received the Golden Microscope Award from the Instituto of Parmacoterapico Italiano.

Professor Baltimore received the Eli Lilly Award at the annual meeting of the American Society for Microbiology and, together with Dr. Howard M. Temin, the Warren Triennial Award from the Massachusetts General Hospital.

Professor Vernon M. Ingram was elected to the Royal Academy, London, England.

Professor Irving London was elected to the National Academy of Sciences.

Dr. Sheldon Penman was promoted to Professor. Doctors Lodish and Paul R. Schimmel were promoted to Associate Professor.

Professor Joel E. Brown is leaving the Department to accept a position as Professor in the Anatomy Department of the Vanderbilt University School of Medicine.

BORIS MAGASANIK

DEPARTMENT OF CHEMISTRY

The number of degrees received in Chemistry during 1970-71 were as follows: 38 Bachelor of Science degrees, 11 Master of Science degrees,

61 Doctor of Philosophy degrees, and one Doctor of Science degree. Most of the graduating seniors elected to attend graduate school. The flexibility of the curriculum in chemistry is advantageous to undergraduates who wish to study in a variety of areas, and this year our graduates will continue in the fall in graduate work in chemistry, physics, education, business administration, and medical school. The placement of Ph.D. candidates met with considerably more difficulty this past year although all candidates were placed in either permanent or temporary positions. About a third of the candidates accepted faculty appointments, a third industrial positions, and a third postdoctoral positions.

PERSONNEL

We record with sorrow the deaths of three colleagues: Professor Charles D. Coryell died on January 7, 1971, after a long illness. He was on the staff at M.I.T. from 1946 to 1971. Professor Emeritus Avery A. Ashdown died on July 15, 1970. His association with the Institute began in 1920. Professor Emeritus Nicholas A. Milas died on January 25, 1971, after a continuous career at the Institute since 1928. Memorial services were held at M.I.T. for each of our colleagues.

Professor Glenn A. Berchtold has been appointed for a five-year term as Chairman of the Department of Chemistry to succeed Professor John Ross, who has completed his five-year term. Professor Ross has been appointed Frederick George Keyes Professor, the chair named in honor of Professor Frederick G. Keyes, Professor Emeritus in the Department.

Professor George H. Büchi has been appointed Camille Dreyfus Professor of Chemistry.

Professor David M. Chipman has resigned to accept an academic appointment at the University of Negev, Beersheba, Israel.

Professor Thayer C. French has resigned from the staff.

Professor E. Lee Gamble was on sabbatical leave during the academic year and retired on June 30, 1971.

Professor Richard C. Holm was on leave of absence at Stanford University during the fall term.

Professor Herbert O. House has resigned to accept an academic appointment at Georgia Institute of Technology.

Professor Gobind H. Khorana, Nobel Laureate, has accepted an appointment in the Departments of Chemistry and Biology at the Institute.

Richard J. Lagow has joined the staff as Assistant Professor.

Paul R. Schimmel has been promoted to Associate Professor.

Each year the Department has the privilege to sponsor a series of

lectures with funds provided from the Arthur D. Little Memorial Visiting Professorship. This year the lectures were given by Professor Ronald C. Breslow, Columbia University, on the subjects "Quantitative Studies on Aromaticity and Anti-Aromaticity," "Biomimetic Chemistry: I. Models for Oxidases," and "Biomimetic Chemistry: II. Reactions in Mixed Complexes;" by Professor Richard N. Zare, Columbia University, on the subjects "Crossed-beam Pyrotechnics," "Stop, Look, and Listen at the Molecular Level Crossing," and "Have Laser, Will Travel;" and by Professor Elliott Montroll, University of Rochester, on "Exciton Migration in Photosynthetic Units," and "Network Models of Electrons in Crystals and Complex Molecules."

CURRICULUM

The undergraduate curriculum changes made in the last few years, particularly those providing a variety of options in beginning the study of chemistry and the integrated undergraduate laboratory, seem to be wearing well. There is much flexibility in choosing subjects while majoring in chemistry and, perhaps in part due to that, the number of undergraduate majors is increasing.

FACILITIES

Renovation of Building 6 (Chemistry) is underway. The basement will continue to be used for shops, the first floor for experimental physical chemistry, the second floor for a theoretical chemistry center, and the third and fourth floors for inorganic chemistry.

The Department is most pleased with the operation of the new Camille Edouard Dreyfus Chemistry Building. Much credit for this goes to Professor John W. Irvine, Jr. for his help in planning the building and attention to all details involved in obtaining and moving into a new laboratory.

The Department received a National Science Foundation Scientific Equipment Grant which is being used to support, in part, the purchase of a photo electron spectrometer.

RESEARCH

Research in the Department of Chemistry is carried out by members of the faculty, postdoctoral research fellows, research associates, and graduate and undergraduate students in a broad range of fields in chemistry and neighboring disciplines, such as biology, nutrition, and geology. A list of publications from the department is prepared every two years. There were 327 publications in the academic year 1970-71.

JOHN ROSS

DEPARTMENT OF EARTH AND PLANETARY SCIENCES

ADMINISTRATIVE CHANGES

To counter a trend toward over-specialization and as an act of faith in the interdisciplinary nature of the planetary sciences, a new administrative structure was planned and implemented. Whereas previously there were separate committees governing the activities of each of the three major disciplines represented in the Department, there will now be single departmental-wide committees covering admissions, curriculum, academic performance, examinations, development, and undergraduate affairs. This will tend to broaden the experience of students in the Department and to bring together faculty members with diverse interests.

Course XII-B, which was planned, implemented, and operated by the Department of Earth and Planetary Sciences, demonstrated a real need for specialized treatment for a small number of M.I.T. undergraduates whose interests and career goals did not coincide with those of the regular departments. Such students were given an opportunity to work out a specially tailored curriculum in conjunction with a member of the faculty who acted as sponsor, protector, advisor, and confidante. With the success of the pilot program the department recommended to the School of Science that it become the sponsor. The Council of the School of Science accepted the proposition and will submit it to the faculty next year for approval under the new name of Interdisciplinary Science.

PERSONNEL CHANGES

Gordon H. Pettengill, formerly director of the Arecibo Observatory, joined the Department as Professor of Planetary Physics. Roger G. Burns, formerly of Oxford University, became Associate Professor of Geochemistry. Christopher Goetze is a new Assistant Professor in Geophysics. Pierre Welander, on the faculty of Göteborg University in Sweden, was with the Department this past year as Visiting Professor in Oceanography. Mehmet N. Toksöz was promoted to Professor, and Carl Wunsch advanced to Associate Professor. Frank Press was nominated to fill the first chair in the Department, the Robert R. Shrock Chair. Gene Simmons was on leave for the year as Chief Scientist at the Manned Spacecraft Center in Houston, Texas. David R. Wones resigned to join the United States Geological Survey. Shawn Biehler resigned to join the faculty of the University of California at Riverside.

A SELECTION OF RESEARCH RESULTS

Radiometric dating in South Korea has disclosed an ancient (2000 m.y.) crustal structure truncated sharply against the youthful Sea of Japan. This has led to an hypothesis in which the ancient crustal blocks in China south of 40°N latitude, and in India, were moved by continental drift into their present place from the south where they formed a bridge between Arabia and Australia. This hypothesis not only permits the matching of broken continental age provinces, but explains several other puzzles, including identity of certain fauna and flora between China and Antarctica, and other southern continents.

A precise radiometric age of 3,375 million years has been obtained on the oldest-known, well-preserved rock section on earth, in Swaziland. It is noteworthy that this oldest sedimentary rock unit also shows strong evidence of having been deposited in the presence of living forms. These include microstructures which morphologically resemble fossil algae and an aromatic type kerogen consisting of aromatic moieties connected by short aliphatic bridges and attached long aliphatic chains.

Refined dating of critical granite plutons strengthens support for a theory that the New England mountains were formed during a near collision of two continental plates which have separated again to form the modern Atlantic Ocean. Emplacement of the plutons was the last stage in a complex sequence of mountain building events which included burial of surface rocks to depths of greater than 15 km accompanied by intense deformation and high grade metamorphism. Rubidium-strontium dating showed that the plutons were not more than 20 million years younger than the rocks they intrude, indicating that the mountains formed during an interval which is very brief by geological standards.

For many years controversy has raged concerning the origin of tektites which are strange, erratic rocks which are found at several widely separated locales on the earth. Elemental abundance comparisons involving 20 trace elements and three major elements of tektites and microtektites from the Ivory Coast and Australasia showed substantial differences from the Apollo 11 and Apollo 12 lunar samples. These data almost close the door on one major hypothesis, namely that the moon is the source of tektites.

Some recent estimates of the vertical diffusivity in the oceans below the surface layer give very low values. If this is substantiated it may be necessary to formulate a new theory for the oceanic vertical circulation. In this connection, it was demonstrated theoretically that the ocean main thermocline, for small vertical turbulent heat diffusivities, was split into two regimes, a diffusive layer next to the surface and an ideal fluid thermocline below.

The existence of an eastward flowing bottom current in the Central North Pacific was demonstrated. This current apparently originates in a bifurcation of the Western Boundary Current that is induced by the bottom topography just north of the Equator. The current then flows east along the flanks of the Mid-Pacific Mountains, through a deep passage only 10 km wide south of Horizon Guyot and on around the eastern end of the Hawaiian Chain. Its dissipation north and east of Hawaii is clearly observed in the temperature structure of the deep water. The existence of this current, whose transport is approximately 20 per cent of the total bottom water flow into the Pacific Basin, was previously unsuspected.

In connection with an undergraduate seminar on the chemistry of Massachusetts environmental waters, some research results of local interest have emerged. Very marked changes in the dissolved constituents in local waters were found with the onset of hot, dry weather. It looks as if by watching the decay of chloride with time from the last de-salting in a given basin, a residence time for the water in that basin can be found. The dissolved silicate concentration also gives a relative residence time for comparison with other streams. The several streams in the Greater Boston area are now being sampled on a routine basis. Each stream is subject to a wide range of influences, and the comparison between streams is now under way.

Geochemical modeling of Venus has produced estimates of the surface condition fully convergent with the results of earth-based radio and radar data and *in situ* spacecraft observations. Strong evidence is emerging to confirm predictions that the topmost cloud layer is composed of very concentrated solutions of hydrochloric acid, while Mariner V data and Venera entry probe measurements reveal a complex cloud structure, presumably containing materials volatilized from the hot surface, deep in the atmosphere. It seems quite possible that chemical reactions between atmosphere and surface buffer diurnal temperature variations to levels below ± 1°K. A study of the photochemistry of the Venus atmosphere appears to have solved the hydrogen-escape and CO_2-recombination problems.

A study of the geochemistry of highly-reduced minerals found in meteorites has led to the hypothesis that conditions during geochemical differentiation of a chondritic Earth may have favored extraction of potassium and the heavy alkali metals into a dense sulfide melt which now constitutes the outer core. Because of the geophysical importance of this postulated presence of large amounts of radioactive material in the core, a laboratory research program is underway on the behavior of potassium in sulfide-containing systems.

The fine structure of quasars 3C279 and 3C273 were discovered at the milli-arcsecond level. The discovery that these structures undergo extremely rapid time variations has profound implications for astrophysics. Observations were made with the Haystack-Goldstone long baseline radio interferometer, which can determine separations of components with accuracies approaching one microarc second.

The Haystack radar observations of Mercury were used to place the first stringent bound on the constancy of the gravitational constant. Any time variation is fractionally less than 4×10^{-10} per year.

Radar observations of Venus were used to discover an extensive mountain range in the equatorial region of that planet.

Radar observations of Mars are currently yielding round-trip echo delays accurate to about one microsecond, corresponding determinations of topography on Mars having an accuracy of 150 meters. This information is vital in locating a suitable landing site for the Viking Mars Lander to be launched in 1975. Because this probe will depend on air drag for its final deceleration prior to a soft landing on the surface, it is vital to locate the very lowest Martian terrain.

The plasma of the solar corona is believed to be accelerated beyond escape velocity to form the solar "wind" by an unknown source of heating in the region from 5 to 20 solar radii. Measurements of the plasma density as a function of radius in this region are essential to determine the nature of the heating, but until now only indirect and ambiguous measurements have been available. A new technique was developed, based on radio observations of pulsars, which yields direct measurements of the mean plasma density over a wide range of distances from the sun. Using the pulsar technique, M.I.T. researchers have measured densities from 5 to 20 solar radii. It was found that the solar wind has not become free-streaming and is still being accelerated at 20 radii.

Observations of the effects of the interstellar medium on the propagation of radio waves from pulsars have found application in an investigation of solar-terrestrial relationships, in which a radio interferometer is being used by NOAA scientists to observe interplanetary-medium effects on pulsar signals. The first observations were made which show time-variation in interstellar dispersion and scattering. These observations are the first to demonstrate that interstellar scattering occurs neither uniformly nor at only one place along the pulsar-observer path; in one case it occurs in just two widely-separated places. The first probable identification of a discrete scattering region, in the Crab Nebula, was made by correlating changes that were observed in the scattering with changes observed by other radio and optical methods.

The spectra of surface waves from submarine earthquakes have been used to obtain the precise depth of focus and the source mechanism of these events. Earthquakes which occur under ocean ridges and fracture zones are extremely shallow, perhaps less than ten kilometers in depth. This may be due to the fact that at greater depth the rocks are so hot in these regions that they creep rather than fracture. One earthquake which was located within the Nasca plate to the west of South America showed that the rocks in the source region were under compression in the direction of plate movement. This implies that the plates may be pushed from the source region toward the subduction zone where they are reabsorbed into the earth's mantle.

MISCELLANEOUS

Professor William F. Brace was elected to the National Academy of Sciences. Professor Emeritus Martin J. Buerger received the Isidor Fankuchin Memorial Award of the American Crystallographic Association. Professor Carl I. Wunsch was awarded the James B. Macelwane Award of the American Geophysical Union, which marks him as the outstanding geophysicist under the age of 30 for the current year. Professor Roger Burns published a book on mineralogical applications of crystal field theory. Professor Frank Press was awarded the Gold Medal of the Royal Astronomical Society and the Distinguished Public Service Award of the United States Department of the Interior.

FRANK PRESS

DEPARTMENT OF MATHEMATICS

The Department of Mathematics has continued to revise and develop its undergraduate curriculum. To allow for the varying preparation in calculus among entering freshmen, Professor Arthur P. Mattuck divided the 18.01 syllabus into six parts. Students could complete each part on their own schedules by passing an examination at any time. Thus about 40 per cent of the freshmen in 18.01 completed the six parts by mid-term and began 18.02 at that time. These students had the option of either completing 18.02 in January or of completing it in the first half of the second term and continuing with a special topic section.

In addition, a version of freshman calculus was offered by Professors David J. Benney and Harvey P. Greenspan, which emphasized the concepts and techniques relevant to science and technology.

Professors Frederic Y. Wan and Alar Toomre extensively revised 18.03, Differential Equations, so that the syllabus would reflect more

accurately the needs of M.I.T. students. Students attended three lectures and one recitation each week; optional tutorial sessions were available.

Developments in algebra included a version of 18.700, prepared by Professor W. Gilbert Strang, which presented computational techniques and applications of linear algebra. Professor Michael Artin has revised the 18.701-2 syllabus.

Participation of the Department in the January Independent Activities Period was coordinated by Professor Strang. A series of hour lectures, presented by faculty and staff, covered topics varying from algebraic topology to employment in mathematics. These were at upper class undergraduate-beginning graduate level, and were intended to be of general interest about current mathematical problems. Nine seminars on special topics in mathematics were conducted by junior staff members. In addition a number of teachers arranged special topics or continuations of courses offered in the fall, where there was indication of student interest.

RESEARCH

The research activity of the Department may be illustrated by the following descriptions of the current research of a few faculty members.

During the past year Professor Prescott D. Crout has continued work on the application of bicomplex functions to multiple armed (spiral and conical) microwave antenna problems. He also extended the concept of complex power and applied it to various wave guide problems. He is continuing to work on the devising of mathematical methods for calculating radar target return.

Research having application in the field of general relativity has been conducted by Professor Philip J. Greenberg. He has derived the Navier-Stokes equation governing the motion of a viscous fluid in the weak field, slow motion, post-Newtonian approximation to general relativity. He is now studying the phenomenon of isotropic turbulence using the derived Navier-Stokes equation.

Professor Victor W. Guillemin's work concerns geometic properties of characteristics of complex of elliptic differential operators. He has developed a first order subelliptic theory, and is attempting to extend the subelliptic theory for higher order operators of Hormander and Egorov to complexes of operators.

Professor Chia-Chiao Lin's study of galactic structure has concentrated on the explanation of the spiral structure of normal galaxies on the basis of stellar dynamics and hydromagnetics. He has placed substantial emphasis on comparison with observations. His report at the

General Assembly of the International Astronomical Union includes the theoretical explanation of ten general observed features and about an equal number of specific comparisons with observational data in external galaxies and the Milky Way System. Observational astronomers are now using his theory to analyze their data.

Professor Franklin P. Peterson has continued his study of the homotopy theory necessary to determine various cobordism theories. He has proved a general algebraic theorem which he hopes will be a main tool in determining PL and TOP cobordism. He also has made some progress in his study of the universal example for secondary characteristic classes defined for normal bundles over n-manifolds. He is also working on the structure of G/TOP as an ∞-loop space.

Working on the cohomology of general linear groups and algebraic K-theory, Professor Quillen has found a definition of higher K-groups $K_i\Lambda$, $i \geqq 0$, for any ring Λ which agrees with the $K_1\Lambda$ of Bass and the $K_2\Lambda$ of Milnor. These groups are the homotopy groups of an H-space with the same cohomology as the infinite general linear group $GL(\Lambda)$. His program now is to compute the cohomology of $GL(\Lambda)$ for interesting rings Λ , such as rings of S-integers in number fields, and then hopefully compute the K-groups. At the moment this has been done for a finite field.

Professor David G. Schaeffer has taken the initial steps toward developing a theory for finite difference approximations of elliptic boundary problems along lines which parallel the well-established theory for the differential problems. Thus far he has restricted his attention to the analysis of boundary value problems on a half space for an operator with constant coefficients, a preliminary step in the analysis of general boundary value problems. He has shown that if the homogeneous problem has only the trivial solution, then the inhomogeneous equation is soluble, and if the difference operator is formally consistent with the differential operator, then the solution of the difference equation tends to the solution of the continuous problem as the mesh parameter tends to zero.

Professor Toomre's work has focused on interacting galaxies, for example, ones where tidal forces still are, or recently have been, quite important. He has found that not only the warped plane of this Galaxy, but also the irregular appearances of both of our neighboring galaxies known as the Magellanic Clouds — and in particular the so-called "bridge" of neutral hydrogen between them — can be adequately explained by a 20 kpc, low-inclination, retragrade passage of both those two galaxies past our own, roughly one-half billion years ago.

Via some restricted three-body computations, Professor Toomre has

also demonstrated that many of the narrow, curving "tails" encountered among other multiple galaxies — and heretofore attributed to magnetic fields, explosions, etc. — can be explained with surprising ease as being just the after-effects of some comparatively recent, violent tidal interactions between such galaxies.

PERSONNEL

New appointments to the faculty made this year are Professor Alberto P. Calderon, Professor Dennis P. Sullivan, and Assistant Professors Eytan Barouch, Eugene M. Kleinberg, and Curtis Greene. The Department received resignations from Professor Eric Reissner, Associate Professor Donald W. Anderson, and Assistant Professors Roe W. Goodman and Michael S. Paterson.

Professors Artin, Hung Cheng, Sigurdur Helgason, Gerald E. Sacks, George B. Thomas, Bernard Maskit, and Harold M. Stark were on leave for part of the academic year. Professors Shoshichi Kobayashi of the University of California at Berkeley, and Philip Saffman of California Institute of Technology were Visiting Professors during the year.

Professor Norman Levinson has been appointed Institute Professor, and Professor Isadore M. Singer has been appointed Norbert Wiener Professor of Mathematics.

Professor Kenneth M. Hoffman has been appointed Head of the Department beginning July 1, 1971. Professors Harvey P. Greenspan and Daniel B. Ray will continue as Chairmen of the Committees on Applied and Pure Mathematics, respectively.

NORMAN LEVINSON

DEPARTMENT OF METEOROLOGY

RESEARCH

The vitality and influence of a small department depends in part on its ability to interact with other groups. This has historically been a significant aspect of the Department of Meteorology's activity — most notably perhaps its collaboration with the Department of Earth and Planetary Sciences and with the Woods Hole Oceanographic Institution in the field of oceanography, and with applied mathematicians in the Department of Mathematics in the field of geophysical fluid dynamics.

The past year has seen a strengthening of the Department's interaction with other groups. The most impressive example is the development of a research project to study Massachusetts Bay, in which

Professor Erik L. Mollo-Christensen and Professor Robert C. Beardsley are collaborating with Professor John M. Edmond in Earth and Planetary Sciences and with Professor Arthur T. Ippen and Professor Donald R. F. Harleman in Civil Engineering, as part of the Sea-Grant program supervised by the Sea-Grant Office at M.I.T. The participants will study the currents, stratification, chemistry, transport of trace substances, and air-sea interaction in Boston Harbor and Massachusetts Bay and will make extensive use of the modern data-gathering facilities which Professor Mollo-Christensen organized in his previous work.

There are other examples of the Department of Meteorology's recent interaction with different groups. During the past year, Professor James M. Austin participated in the air pollution aspects of a special project course, organized by the Department of Chemical Engineering, on environmental problems. A joint five-year proposal with Lincoln and Draper Laboratories has been submitted through the Department of Meteorology to the Environmental Protection Agency for the study of meteorological aspects of air pollution.

During the past year, Professor Henry M. Stommel, with the assistance of Professor Allan Robinson of Harvard University, has organized a multi-institutional project with participants from seven American and one British institution. The project, called PREMODE, is being sponsored by the National Science Foundation. Investigators will observe in detail the motions, temperature, and salinity in a small area of the sub-tropical North Atlantic. Oceanographers, in their reasoning about how the general features of the ocean circulation and structure are created and maintained, have never had the benefit of an equivalent to the daily routine observational network which has been available to their atmospheric counterparts. This is because there has been no oceanic equivalent to the problem of daily weather forecasting so that such a network could be justified financially. The importance of the transport of mechanical and chemical properties by time-variable motion in the ocean has therefore remained almost completely a matter of theoretical reasoning and conjecture. To remedy this deficiency, PREMODE is planned as a preliminary exercise to aid in the design of a later, more extensive, international program to obtain such data over a much larger oceanic area. These studies are part of the International Decade of Ocean Exploration.

A brief description of several research projects in process over the last year can provide a sample of current work in the Department.

The dynamics of weather systems in low latitudes involves a complicated process in which small-scale cumulus convection is organized spatially as a heat source for storms having a larger scale. One study

has shown how the latent heat released in the Indian summer monsoon creates an upper-level westward flowing jet stream south of the subcontinent. Another study has shown that the central part of equatorial Africa is a region of formation for westward-moving circulation systems which later appear in the cloud maps obtained by satellite photography. The tropical studies, which are being continued by Professor Frederick Sanders, Professor Jule G. Charney, and several students, will be of increasing importance as the 1974 tropical observation program of the Global Atmospheric Research Program approaches.

The spectral distribution of energy in atmospheric and oceanic motions is another subject of current interest, especially since Professor Edward N. Lorenz showed several years ago that small-scale observational errors would severely limit the predictability times of large-scale motion if the intervening spectrum were similar to that of inertia turbulence (for example, energy density proportional to wave number of the minus 5/3 power). Professor Charney has suggested theoretical reasons why a different spectral law should hold for three-dimensional atmospheric motions, while Professor Peter B. Rhines has shown how the roughness of the sea floor and the spherical shape of the earth can each modify the wave-number spectrum to be expected in the ocean. Professor Reginald E. Newell and several of his former students have just completed an extensive monograph supported by the Atomic Energy Commission describing the large-scale properties and general circulation of the tropics. The monograph is being published by the M.I.T. Press.

STUDENT ENROLLMENT

The number of full-time students in the Department in September, 1971, is expected to be 52, somewhat less than in September 1970. This is because the unusually large number of terminal degrees recently awarded (39 between September, 1969, and September, 1971) has slightly exceeded the slowly increasing admission rate for new students. Since fewer degrees will be awarded in the next two years, enrollment is expected to increase. The Department has historically been able to support many students as research assistants. It appears that this support can be increased slightly, which is especially fortuitous in view of the forthcoming general reduction in fellowship support of graduate students.

Although the job market for graduates of the Department of Meteorology has held up quite well, it may be necessary for the Department to expose its students to a wider range of subject matter and to be even more selective in its admissions policy, as its graduates come into competition

with those graduates in physics and chemistry who are shifting towards a specialization in physical and chemical aspects of the atmosphere and ocean.

PERSONNEL

Professor Henry G. Houghton, in his first year on emeritus status, has continued to take an active interest in both the Department and the Institute and will continue to teach atmospheric physics. The Department regrets the loss of Professor Rhines, who will hold a research position in Cambridge, England, where he received his doctorate. Because Professor Rhines' work is in theoretical oceanography, and because Professor Delbar P. Keily, who specializes in atmospheric physics and instrumentation, will be the next faculty retirement, the Department sought an atmospheric scientist, trusting that the physical oceanography faculty, with support of the Woods Hole staff in the Joint Program, could stand a temporary strain. As a result, Assistant Professor Ronald Prinn has been appointed to the faculty to pursue work in the chemistry and radiation of planetary atmospheres. Atmospheric chemistry, a new field for the Department of Meteorology, has been instituted because of increasing concern about pollution, and because of the accumulation of enough data from Venus, Mars and Jupiter to enable interesting questions to be posed about their atmospheres. Professor Newell will be on sabbatical leave next year, visiting Imperial College in London and the Max Planck Institute for Chemistry in Mainz. During much of the year Professor Victor P. Starr was hospitalized but he has now recovered and resumed his research on the circulation of the atmospheres of the earth, sun, and Jupiter.

An unusually large number of outstanding awards were presented to the faculty this past year. Professor Mollo-Christensen received the 1970 von Karman Award from the American Institute of Aeronautics and Astronautics; Professor Phillips received the Carl-Gustav Rossy Award of the American Meteorological Society, and Professor Stommel received honorary doctorates from Yale and the University of Chicago. Professor Charney was elected to the Norwegian Academy of Science and was awarded an honorary doctorate from the University of Chicago, and he received the International Meteorological Organization Prize of the World Meteorological Organization. Dr. John Raphael Bates of the Irish Meteorological Service was awarded the Sir Napier Shaw Prize of the Royal Meteorological Society for work on this general subject growing out of his thesis performed here two years ago under Professor Charney.

NORMAN A. PHILLIPS

DEPARTMENT OF NUTRITION AND FOOD SCIENCE

The Department of Nutrition and Food Science has distinguished itself through faculty research, number and quality of students and post-doctoral fellows, and national and international recognition. Although training grant funds were restricted, fewer government fellowships were awarded, and many government research grants and contracts were curtailed or eliminated, it was possible to obtain alternate funding for support of the same number of students as in the last two years.

DEVELOPMENT OF RESEARCH PROGRAMS

Several new programs, such as the "Epidemiological Study of Malnutrition in Greater Boston," and program projects in food toxicology, enzymology, and the identification of environmental toxicants, are both multidisciplinary and mission-oriented, and are headed by faculty members in diverse fields. The Department reaffirmed its mission orientation by focusing on the areas of nutritional biochemistry and metabolism, food toxicology, food science and technology, and biochemical engineering.

STUDENT ENROLLMENT

In addition to 100 graduate students registered as degree candidates in Nutrition and Food Science, 11 students are doing thesis work in the Department while earning degrees in other Departments, including Biology, Psychology, Mechanical Engineering, Chemical Engineering, Electrical Engineering, and Civil Engineering.

There has been a continuing increase in undergraduate subject enrollment, which is attributable to changes both in Departmental subject offerings and in interests of undergraduates. In addition, 20 undergraduates signed up to do research with various department faculty members. Several factors have contributed to increased involvement of department faculty members with undergraduates, among them faculty participation in the Interdisciplinary Environmental Council and the availability of subjects relevant to the proposed new Division of Health Sciences and Technology.

Within the Life Sciences Program, both the Nutritional Biochemistry and Metabolism option and the Food Science and Technology option are available to undergraduates.

CURRICULUM DEVELOPMENT

During the past year, the graduate teaching program in Nutritional Biochemistry and Metabolism has been reviewed by both students and

faculty, resulting in a continued trend towards more training in the basic biological study of man and other mammals. The philosophy behind this orientation is that the M.I.T. life sciences curriculum does not now provide specific subject work in mammalian biochemistry and physiology. The Department of Nutrition and Food Science feels equipped to provide such subjects, compatible with the Department's goal of teaching nutritional principles.

The new curriculum will combine under one sequence most of the mammalian biochemistry and metabolism material previously given in subjects 20.33, Nutritional Biochemistry and Metabolism; 20.34, Advanced Nutritional Biochemistry and Metabolism; and 20.391-4, Mammalian Protein and Nucleic Acid Metabolism, Carbohydrate and Lipid Metabolism, Vitamins in Metabolism, and Mineral Metabolism. This material will henceforth be taught as a two-term subject, Mammalian Biochemistry and Metabolism I and Mammalian Biochemistry and Metabolism II, for 12 credit hours per week. Subject 7.05, General Biochemistry, will be a prerequisite for these subjects also, but graduate students will receive credit for satisfactory performance in this subject.

A new subject, Mammalian Nutrition, will be developed to cover mammalian nutritional principles in general and will become a mandatory part of the core curriculum. This subject will deal with the role of nutrients in both man and animals and with consequences of deficiencies and imbalances. The existing subject, 20.36, Human Nutrition, will be modified to provide an advanced treatment of human nutritional problems at the metabolic, clinical, and public health level.

Biochemical and Biophysical Techniques, 20.32, will be presented as an elective with the approval of the graduate student's supervisor. It will be a nine-credit lecture subject with an associated nine-credit practical laboratory, 20.321. The 20.391-4 series will be retained as optional subjects on topics in metabolism.

In addition to in-depth subjects on mammalian biology and nutrition, the Department has developed several subjects to apply these basic experiences to human needs and problems. These subjects include the seminar on World Population and Food Problems, 20.75, Nutrition, Growth, and Development, 20.35, two subjects on field studies in human nutrition, 20.361-2, and Environmental Factors in Food Quality, 20.38.

CONFERENCES, SYMPOSIA, AND SPECIAL SUMMER COURSES

On October 19-21, 1971, the International Conference on Nutrition, National Development and Planning will be held at M.I.T. under the Chairmanship of Professor Nevin S. Scrimshaw of M.I.T., Professor David L. Call of Cornell University, and Mr. Alan Berg of The Brook-

ings Institution. This conference will provide an opportunity for international experts in planning, nutrition, and related development disciplines to seek a fresh view of the importance of nutrition in national development and to initiate a more systematic approach to national nutritional planning.

On September 24, 1970, as part of the Eighth Annual Underwood-Prescott Memorial Lectureship, a symposium on "Food Quality and Flavor Research" will be held at M.I.T. with participants from several universities and industrial organizations. This year's Underwood-Prescott Symposium, on September 23, deals with "Developments in Food Processing and Food Engineering for the 1970s."

During the summer of 1971, the department is offering three special short subjects: Enzymes and their Use for Analysis and Clinical Diagnosis, under the direction of Drs. Samson T. Jacob, George Wolf, and Jean-Pierre Flatt; Fermentation Technology, under the direction of Daniel I. C. Wang; and Principles of New Processes for Food Concentration, under the direction of Dr. Samuel A. Goldblith.

FACULTY CHANGES

Effective July 1, 1971, Dr. Robert S. Lees, Associate Professor of Metabolism and Human Nutrition and Director of the Clinical Research Center, was promoted to the rank of Professor. Dr. Anthony J. Sinskey became Associate Professor of Applied Microbiology.

New appointments include Dr. Gustav Schonfeld, Associate Professor of Metabolism and Human Nutrition and Assistant Director of the Clinical Research Center; Dr. Roland Davies, Assistant Professor of Food Microbiology; and Dr. James M. Flink, Assistant Professor of Food Engineering. Dr. Gordon S. Myers and Dr. Abraham E. Nizel were appointed Visiting Associate Professors.

Faculty resignations included Drs. Edwin D. Bransome, Jr., Theodore P. Labuza, John E. Harris, and Dana E. Wilson. Dr. John T. R. Nickerson, Professor of Food Technology, who since 1948 has been responsible for teaching many courses in food processing and microbiology is retiring this year.

NEVIN S. SCRIMSHAW

DEPARTMENT OF PHYSICS

In common with departments all over the country, the M.I.T. Department of Physics has had a year of painful belt-tightening. This has necessitated some decrease in faculty, staff, and graduate students, and in the

scale of departmental activities generally. Although all the main programs have been maintained and the number of degrees awarded during the year in every category (127 S.B., 26 S.M., and 66 Ph.D.) showed a substantial increase over the previous year, future years will necessarily be expected to show a diminution of these figures.

The instructional programs of the department have not undergone any major changes in the past year, but there have been some promising experiments with self-paced study programs in the subject matter of the basic introductory subjects for limited numbers of students. The department plans to extend the amount of its teaching in this mode. The biophysical version of first-year physics, developed and taught by Professor George B. Benedek, proved to be a considerable success and a second-year sequel to it will be given in 1971-1972. The department had a total of about one hundred students in the new Undergraduate Research Opportunities Program.

During the January Independent Activities Period the department offered a wide variety of activities, including 30 seminars, an intensive subject in laboratory glassblowing, and visits to the National Magnet Laboratory and Woods Hole Oceanographic Institution.

RESEARCH

ASTROPHYSICS

The technique of very-long-baseline-interferometry (VLBI), with better than optical resolution, has revealed changes in the structure of quasars, with apparent motions faster than light. Observational and theoretical studies of the phenomenon will continue. VLBI has also been used to study interstellar water-vapor masers and indicates source sizes smaller than the solar system. The time dependence of microwave emission from various sources has been analyzed.

In X-ray astronomy, balloon experiments have discovered two new X-ray sources. Rocket experiments have tentatively identified another X-ray source (Cygnus X-1) with a visual/radio stellar source. In preparation are several satellite experiments to study many details of galactic X-ray emitters and interstellar absorbers. High-resolution X-ray spectroscopy is an important component of this research.

Experimental and theoretical work has continued on plasmas in space, with emphasis on MHD shocks and on "stellar winds" as dissipators of stellar angular momentum.

Theoretical studies of stellar evolution have shown that inherent dynamical instabilities in red giants may account for their turning into white dwarfs rather than neutron stars in most cases. Detailed analysis of Cepheid variables has indicated that the Hubble time of the universe

has been underestimated by 12 per cent. A promising theory of the population evolution of quasars and similar objects has been based on the spinar model. Theoretical studies have also been made on the double radio source Cygnus A, on the polarization state of the Crab pulsar spectrum, and on the supernova model of the Gum nebula.

EXPERIMENTAL NUCLEAR AND HIGH-ENERGY PHYSICS

The research programs in both experimental and theoretical nuclear and particle physics have, as usual, been under the aegis of the Laboratory for Nuclear Science.

Although activities in Experimental Nuclear and High-Energy Physics have been very significantly affected by reductions in funding, a strong research program has been maintained, in large measure by making use of off-campus facilities. Low-energy nuclear reaction physics has been done mostly at Brookhaven undertaken primarily through particle analysis by the M.I.T. sector magnetic spectrometer installed there. Intermediate-energy experiments on nucleus-electron scattering have been conducted on the National Bureau of Standards linear accelerator, and have yielded information on nuclear form factors and electromagnetic transition rates. In the high-energy field, electron-scattering experiments by M.I.T. researchers at the Stanford linear accelerator have provided evidence for a possible infrastructure (quarks or "partons") within the proton. Photon-induced processes at high energy have been studied at the Cambridge Electron Accelerator and at the Deutsches Elektronen Synchrotron; research involves detailed tests of vector-dominance theory. Proton-antiproton annihilation processes leading to totally neutral final-state particles have been studied at the Brookhaven alternating-gradient synchrotron.

Analyses of pion-proton interactions with the automatic film-scanning system (PEPR) have been continued and have reached record speed and precision.

A major part of the effort in nuclear physics has continued to be towards completion of the L.N.S. 400 Mev electron linear accelerator at Middleton, Massachusetts, and towards the design and construction of its energy-loss spectrometer. An initial 100 Mev beam from the accelerator is scheduled for late 1971.

Three of the M.I.T. high-energy experimental groups are preparing to do experiments on the 500 Gev National Accelerator at Batavia, Illinois.

NUCLEAR AND PARTICLE THEORY

The main research of the Center for Theoretical Physics continues to be

in the study of the underlying simplicities in the interactions and stationary states of nuclei and elementary particles. The relativistic quark model has been used as a basis for understanding the interaction of hadrons with leptons with large momentum transfer, in particular the deep inelastic scattering of electrons by nucleons, the inelastic scattering of neutrinos and the creation of muon pairs by proton-proton collisions. The radiative transitions of the low-lying baryon states have also been examined using composite models for elementary particles.

Much of the work in theoretical particle physics has been stimulated by the prospect of having 500 Gev protons at the National Accelerator Laboratory and proton-proton collisions of even higher energy at CERN. Possible phenomena, interaction mechanisms, and experiments have been considered. The theoretical techniques include energy and momentum scaling properties, complex angular momentum analysis, higher symmetries exhibited by the particle states and the use of specific models as guides.

In nuclear theory, the implications of relativity for the nucleon-nucleon interaction at short distances are being reexamined. At a more phenomenological level, studies have been made of the importance for nuclear structure calculations of the behavior of the nucleon-nucleon scattering amplitude off the energy shell. It has been found that binding energies are very sensitive, but that matrix elements between shell model states are insensitive. A new program has been begun on the use of a density-dependent semi-phenomenological Hamiltonian for nuclei, beginning with a fit to the properties of spherical nuclei and extrapolating to others. The method is being applied to superheavy elements and to heavy ion collisions. In scattering theory, studies have been made of the scattering of 1 Gev protons by carbon and of the role of triple scattering in the optical model of such scattering.

One interesting development has been the growing overlap of nuclear and particle theory with astrophysical problems, especially in connection with the properties of very dense hadronic matter at temperatures above 10^{12}°K.

SOLID-STATE, LASER AND ATOMIC PHYSICS

In plasma physics, the main effort has been directed toward the ALCATOR project (construction of a large toroidal plasma-containment device with the prospect of achieving thermonuclear fusion). The device should be tested early in 1972. The plasma group has also investigated dense, hot plasmas generated by megawatt laser beams; forbidden optical transitions have been observed. In the field of solid-state physics, high-power operation of a spin-flip Raman laser in InSb has been achieved.

Also, spin-dependent tunneling in superconductive Al has been observed. Details of this and other work are given in the report of the Francis Bitter National Magnet Laboratory. The vortex lattice of a type II superconductor has been studied via spin-flip of an atomic beam passing over the surface of the material.

Studies of light scattering have yielded information on the existence and properties of a two-roton bound state in liquid helium. A detailed program of research has been carried out on liquid crystals, with special reference to the phenomena associated with their phase transitions.

Research on atom-atom scattering in beams has yielded much information on the singlet and triplet states of systems such as Na-K, and has indicated a weakly bound triplet molecular state of the system. The neutron scattering group has studied the diamagnetic scattering of metallic bismuth.

In quantum electronics, emphasis has been on precision spectroscopy. A laser frequency is being compared directly with a microwave source, and the wavelength is being measured interferometrically. A new, precision value of c should result.

Finally, the coupling of acoustic and electric surface waves in a medium placed in a magnetic field has been demonstrated experimentally.

RADIOACTIVITY CENTER

The Radioactivity Center, under the direction of Professor Robley D. Evans, is now associated with the Center for Human Radiobiology, which was recently established by the Atomic Energy Commission at the Argonne National Laboratory. The Center for Human Radiobiology was created to assure a long-term commitment to studies of the radiobiological effects of skeletally deposited radioactivity in humans. Such investigations have been an important component of the Radioactivity Center research program since 1934.

The M.I.T. Radioactivity Center studies of human cases of radium and mesothorium deposition have provided the basis for the present international radiation protection guides for internal emitters such as radium, plutonium, and strontium-90. During the past year, the number of patients studied in the M.I.T. Department of Physics in collaboration with the M.I.T. Medical Department and the M.I.T. Clinical Research Center has increased to more than 700. The radium patients in these studies are members of a unique group of humans who have experienced continued radiation exposure over a period of 40 to 50 years. It is expected that these cases be followed throughout the patients' lifetimes — beyond the year 2,000.

Statistically, the biological response among these patients to skeletal

doses of alpha-radiation unequivocally contradicts the so-called linear model of radiation injury. Findings of the Radioactivity Center indicate that repair and recovery mechanisms in the human body can cope with rather large amounts of radiation before reaching a threshold dosage level above which radiation injury in the form of malignancy is seen in about 30 per cent of the patients.

Knowledge of the dose-response relationships for humans is a determining factor in many technical, economic, and political aspects of nuclear power generation. Small amounts of radioactivity in the effluents from nuclear power plants, fuel reprocessing plants, and Plowshare activities would be innocuous, if there is a practical threshold in the dose-response relationship for all deleterious radiation effects. If there is no threshold in some deleterious human response, much more severe engineering restrictions would be necessary.

PERSONNEL

The following faculty members received promotions to Associate Professor as of July 1, 1971: James D. Litster, William K. Rose, and H. Eugene Stanley.

New faculty members in the department are Assistant Professor Donald S. Barton, Ulrich J. Becker, John W. Belcher, Hans D. Betz, John W. Negele, and Robert J. Taylor.

This year Professor Peter A. Wolff has become Head of the Department's Division of Atomic and Solid State Physics.

Professor Philip Morrison was elected to the National Academy of Sciences. Professors Bernard F. Burke and Alan H. Barrett were co-recipients of the Rumford Medal of the American Academy of Arts and Sciences, in recognition of their achievements in very-long-baseline interferometry. Professor Bruno B. Rossi was awarded the International Feltrinelli Award from the Accademia dei Lincei.

VICTOR F. WEISSKOPF

GRADUATE SCHOOL

Stimulated by the *Report of the Commission on M.I.T. Education,* the Graduate School has devoted much of the past year to a reexamination of graduate education at M.I.T. Both the Committee on Graduate School Policy (C.G.S.P.) and the Graduate Student Council have contributed to this study. As a result of reexamining its role, the C.G.S.P. has in large part turned over to the Graduate School Office and to departmental graduate committees routine housekeeping functions, thereby leaving itself free to devote most of its time to policy matters. In particular, it has been concerned with the development of new and innovative approaches to graduate study and has set up a subcommittee chaired by Associate Dean Sanborn C. Brown, to initiate educational programs at the graduate level. Special attention has been devoted to interdisciplinary graduate programs, and it was decided that the Dean of the Graduate School should appoint a faculty committee to study each proposal prior to its consideration by C.G.S.P. During the past year, the Graduate Student Council has played an increasingly important and responsible role not only in dealing specifically with graduate student problems but by examining and reporting issues of more broad concern throughout the Institute.

ENROLLMENT OF GRADUATE STUDENTS

The period of rapid growth of the Graduate School in the postwar years ended in 1965 when enrollment reached 3,200 regular degree candidates. Since that time it has risen slowly, and it was 3,300 in 1970.

In addition to regular students, there were, in 1970, 383 Special Graduate Students not enrolled for a degree. Some 1,301 Master's, Engineer and doctoral degrees were awarded during the year (see Table II).

The causes of this plateau in the growth of the graduate student population are not difficult to discover. An important factor at first was the change in Selective Service regulations which ended deferments for graduate students. Far more significant, however, has been the curtailment of Federal funds for the support of graduate fellowships and scholarships. Compared with 1967, the Woodrow Wilson Foundation estimates that the number of Federal fellowships in 1971 will decrease 62 per cent nationally. The trend continues, and by next year many Federal fellowship programs will terminate completely. A third factor which is beginning to have an effect on graduate student enrollment is the generally depressed state of the economy, with its accompanied unemployment of the professionally-trained. For example, unemployment in the aerospace and related industries is already reflected in a decrease in the enrollment of students in the Department of Aeronautics and Astronautics. The combination of decreased Federal fellowship support and diminished employment opportunities is expected to result in some decrease in graduate enrollment in the coming year, although M.I.T. may not be affected as much as some institutions.

FELLOWSHIPS, SCHOLARSHIPS, AND ASSISTANTSHIPS

The impact of the curtailment of Federal financial support for education has only just begun to be felt during the past year, and some 88 per cent (compared with 90 per cent for the previous year) of the graduate students received awards of either tuition plus stipend for living expenses or tuition alone. Some 996 students served as part-time research assistants with their stipends paid from research grants. Another 505 served as teaching assistants and about 50 others are resident tutors in the dormitories.

Unfortunately industrial and foundation fellowships have not increased in number to offset the decrease in Federal funding (see Tables III, IV, and V). Although foundation fellowships have remained constant, industrial fellowships have actually decreased substantially due to the state of the economy.

A few (125) graduate students have been helped by bank loans arranged through the Student Financial Aid Office. Such loans take care of emergencies only and realistically cannot constitute the sole

support of a doctoral student for the five years required to earn the degree. Unless new funding can be found for graduate students, a decrease in graduate enrollment can be expected, especially in private universities in the United States.

In response to the emergency presented by the precipitous drop in Federal fellowships, the M.I.T. Administration has allocated funds from the Sloan Basic Research Fund to establish graduate fellowships during the coming year. Some 90 fellowships, called Sloan Research Traineeships, have been allocated primarily in science and engineering. These traineeships are roughly equivalent to the Federal fellowships which they replace and are awarded to graduate students who participate in research in addition to course work. The establishment of these Sloan Traineeships has gone a considerable way in alleviating the crisis in graduate student support for the 1971-72 year.

NEW GRADUATE PROGRAMS

No single department can hope to deal adequately with such broad problems as the urban blight, pollution, ecological imbalance, overpopulation, health care, oceanography, and energy and natural resources. As M.I.T. has moved away from strictly defense-oriented research, keen interest has developed on the part of both faculty and students in working on societal problems of an interdisciplinary nature. Already approved and operating interdisciplinary programs exist in oceanography (administered jointly with the Woods Hole Oceanographic Institution), economics and urban studies, instrumentation, materials science, and operations research. During the past year, the Committee on Graduate School Policy has devoted major attention to proposals for interdisciplinary programs as follows: social applications of technology, biomedical engineering, public systems engineering, college teaching, dynamic behavior of social systems, and health sciences and technology (a cooperative program with the Harvard Medical School). Faculty committees appointed by the Dean of the Graduate School have studied many of these proposals and in the case of the biomedical engineering program, approval has been granted by the C.G.S.P. An interdisciplinary faculty standing committee has been set up to supervise this interdepartmental program in the School of Engineering. In the case of other interdisciplinary programs, less formal arrangements are available for accommodating individual students, and each graduate student will be supervised by an *ad hoc* committee composed of faculty in the particular interdisciplinary area. The *ad hoc* committees

report to the Dean of the Graduate School who is responsible for interdisciplinary programs.

As interdisciplinary research areas have developed, so has evolved a need for courses not offered by M.I.T. but available at other institutions. Arrangements have been made for exchanges of students by cross-registration with Harvard University, Wellesley College, Woods Hole Oceanographic Institution, and, on a restricted basis, with Tufts University, Boston University, and Brandeis University. In some cases a cooperative arrangement also applies to the use of shared facilities and equipment for research.

SELECTIVE SERVICE

The introduction of a lottery system for drafting 18-year-olds for the armed forces, together with a decrease in the monthly draft calls, has decreased the student load on the M.I.T. Selective Service Office. This has made possible the merging of the undergraduate and graduate Selective Services Offices into a single one, supervised by Associate Dean Sanborn C. Brown. With the elimination of all student deferments anticipated in the future, the Selective Service Office will assume as its primary role the advising of students on problems relating to the draft.

DISADVANTAGED MINORITY STUDENTS

Strenuous efforts have been made during the past three years to increase the number of disadvantaged (especially black) graduate students. This program involves recruitment efforts, special tutorials, and fellowship support for these students. Chancellor Paul E. Gray and the M.I.T. Task Force on Educational Opportunity are responsible for leadership in this campaign. Special credit for recruitment is due Mrs. Dorothy Owusu, Administrative Assistant in the Office of the Dean of the Graduate School. These combined efforts have resulted in a dramatic increase in the number of black graduate students from 16 in September 1968 to 52 in September 1970. Some 80 black graduate students are expected in September 1971. Combined efforts by the President, the Provost, the Dean of Engineering, and the Dean of the Graduate School, plus individual departments, have resulted in the generation of funds during the current year for the support (tuition plus cost-of-living stipend) for all entering black graduate students.

During the coming year plans call for the recruitment of other

minority groups, in addition to the continuing program with black Americans. Funding such a program may prove difficult, however, and will require very special effort.

WOMEN GRADUATE STUDENTS

Although the increase in the number of undergraduate women is well known, it is rewarding to learn that there has been a comparable increase in the number of graduate students who are women. In 1967-68, there were only 90 women, but by 1970-71 this number had risen to 280. The proportion of women in the Graduate School is expected to increase in the next few years. Financial aid for women graduate students is in every way comparable to that for men and hence poses no unique problems.

GRADUATE STUDENT AFFAIRS

During the past year, the Graduate Student Council has been playing a more responsible and important role both in academic and extracurricular matters and has functioned very well as a spokesman for the graduate students. It has operated the Muddy Charles Pub most successfully as a social center where graduate students and faculty can meet in an informal, congenial atmosphere. It has also become a center where the Graduate Student Council can hold joint meetings with the Committee on Graduate School Policy and other student-faculty committees. In September 1970, the Graduate Student Council, in collaboration with the Office of the Dean for Student Affairs and the Graduate Dean's Office, sponsored a very successful orientation and reception for new graduate students in the Stratton Student Center. The Executive Committee of the Graduate Student Council also holds frequent discussions with the Graduate School Office staff concerning current problems affecting graduate student life at M.I.T.

HOUSING

Graduate housing has been inadequate for many years and as a result most graduate students, both married and single, have had to live off campus. A few years ago, an Institute Housing Committee, which included faculty, staff, and graduate students, was set up to plan a new apartment complex to house 400 single men and women. Funding is now complete and construction of this new graduate house, temporarily named Westgate II, is well under way. It is expected that the building

will be ready for occupancy in the summer of 1972 and that it should relieve the housing shortage for graduate students.

PLACEMENT

In view of the recent scarcity of jobs for professionals, it has been necessary to devote special attention to this problem. Under the able direction of Mr. Robert K. Weatherall, Director of Placement and Assistant Dean of the Graduate School, considerable progress has been made, with the result that nearly all of the graduate students receiving degrees have found suitable employment.

In cooperation with the Placement Office, the Alumni Office, and the Graduate School Office, a successful two-day Alumni Seminar on "Career Opportunities" was held in April 1971. Associate Dean Sanborn C. Brown is now in the process of preparing the seminar addresses for publication by the M.I.T. Press.

FOREIGN GRADUATE STUDENTS

During the past year, a study was made of foreign graduate students with reference to admission policy and financial support problems, as well as consideration of a proper balance between domestic and foreign students. The difficulty of finding financial support for foreigners has been intensified by economic problems in various parts of the world. M.I.T., with its very high proportion (28 per cent) of foreign graduate students, is presented with special problems in this regard. Hence the Graduate School Office will need to devote special attention to the foreign student population in the coming year.

QUALITY OF GRADUATE EDUCATION

Every five years the American Council of Education has attempted to evaluate graduate education in the U.S. colleges and universities. In 1971, it published a report entitled "A Rating of Graduate Programs" by Kenneth D. Roose and Charles J. Anderson, which presented an evaluation based on "quality of graduate faculty" and "effectiveness of doctoral program." In most of the areas in which it offers graduate degrees, M.I.T. was listed among the top half dozen institutions in the country, as evaluated by both criteria. In addition, the report indicated that the quality of graduate education at M.I.T. has improved as compared with the survey made five years ago. A completely independent study lists M.I.T. as one of the five top educational institutions in the world.

With these encouraging indices of quality, M.I.T. will strive to improve its Graduate School even further in the years ahead, while at the same time coping with serious problems of graduate education.

IRWIN W. SIZER

Table I-A Graduate School Quotas and First-Term Registration, 1970-71

	All Schools	Engineering	Science	Architecture and Planning	Humanities and Social Science	Management
Quota	3,443	1,650	1,006	209	278	300
Registration	3,296	1,533	973	215	253	322

Table I-B History of Quotas and Registration, All Schools, 1966-1970

	1966	1967	1968	1969	1970
Quota	3,232	3,342	3,342	3,420	3,443
Registration	3,198	3,344	3,274	3,395	3,296

Table II Graduate School Statistics, 1970-71

Advanced Degrees Conferred:	B.Arch.	M.Arch. & M.C.P.	S.M.	Engineer	Sc.D.	Ph.D.	Total
September 1970	2	5	187	16	15	113	339
						1(WH)**	
February 1971	2	3	146	25	23	100	300
					1(WH)**		
June 1971	14	29	400	72	24	122	662
						1(WH)**	
Total	**18**	**37**	**733**	**113**	**63**	**337**	**1,301**

Graduate School Registration (Includes Regular and Special Students)	Summer 1970	Fall 1970	Spring 1971
School of Engineering	933	1,754	1,621
School of Science	711	1,019	952
School of Architecture and Planning	21	264	243
School of Humanities and Social Science	132	287	274
Sloan School of Management	87	355	340
Total	**1,884**	**3,679***	**3,430**
Regular Students	1,846	3,296	3,124
Special Students	38	383	306

* 2,745 = U.S. and Canadian Students
934 = Other nationalities
** Joint degree with Woods Hole Oceanographic Institution

Table III Summary of Graduate Financial Assistance for 1970-71

Total Regular Graduate Students	3,296	
Federal fellowships and traineeships	735	(22%)
Graduate student staff	1,501	(46%)
Industrial and foundation awards	108	(3%)
M.I.T. endowed and budgeted funds	132	(4%)
Students sponsored by external sources	421	(13%)
Total Awards	2,897	(88%)

Table IV Graduate Student Support

The sources of support for most of the M.I.T. graduate students in 1970-71 are listed. However, a single table is an incomplete reflection of the total picture, since support shifts constantly throughout the academic year in accordance with changing student status, early termination of degree program, the draft, and so on. Because of the statistical problem created by this constant change, this table was devised to present a representative "snapshot," in effect. For purposes of this count, a full award was considered as at least full tuition support during the fall term 1970.

Fellowships and Traineeships awarded by M.I.T.		
National Defense Education Act Traineeships	80	
National Science Foundation Traineeships	141	
National Institutes of Health and other Health, Education, and Welfare (HEW) Traineeships	160	
Industrial and Foundation Fellowships	72	
M.I.T. Endowed and other Fund Fellowships	132	
NASA Stipend/M.I.T. Endowed Fellowships	6	
Total		591
Fellowships awarded by sponsors to M.I.T. students		
Atomic Energy Commission Fellowships	25	
National Science Foundation Fellowships	267	
National Institutes of Health and other HEW Fellowships	41	
National Aeronautics and Space Administration International Fellowships	3	
Housing and Urban Development Fellowships	7	
Woodrow Wilson Dissertation/M.I.T. Endowed	4	
Hertz Foundation Fellowships	23	
Danforth Foundation Fellowships	5	
U.S. Department of Labor Fellowships	4	
U.S. Department of Justice Fellowships	1	
Ford Foundation Minority Fellowships	4	
Total		384
Student Assistantships — Research	996	
Teaching	505	
Total		1,501

Table IV Graduate Student Support (cont.)

Sponsored Students			
Many students are known to be receiving support from employers and sponsors. The following reflects Bursar's billings for tuition to such employers and sponsors, who presumably provide stipends to such students by private arrangements.			
U.S. government agencies	228		
Industry and foundations	123		
Foreign countries and international programs	70		
Total		421	
Total: Students considered to have received full awards academic year 1970-71			2,897
Partial awards, loans, and miscellaneous programs — tuition or lesser amounts. Individual student support in many cases is derived from partial awards ranging from $100 to $3,000 each. In many cases, an accumulation of partial awards and/or loans provides a student with essentially complete support. As a result, the number of such partial awards does not reflect the number of student recipients.			
Partial Awards			
Sloan Executive Fellows	47		
M.I.T. Endowed and Special Budget	70		
Industrial and foundation	26		
National Science Foundation Summer Traineeships	8		
Total		151	
Loans			
Total M.I.T.-administered loans	478	($319,000)	
Total M.I.T.-administered bank loans	118	($164,000)	
Total		596	
Total: Partial awards and loans			747

Table V Federal Awards to M.I.T. Graduate Students

	Atomic Energy Commission	Housing and Urban Development	National Aeronautics and Space Administration	National Defense Education Act	National Science Foundation Traineeships	National Science Foundation Cooperative	National Science Foundation Fellowships	Total
1951-1952								
1952-1953					48			48
1953-1954					46			46
1954-1955					51			51
1955-1956					61			61
1956-1957					64			64
1957-1958	26				64			90
1958-1959	35				92			127
1959-1960	43			4	100	39		186
1960-1961	39			14	102	40		195
1961-1962	39			25	152	42		258
1962-1963	34			29	165	44		272
1963-1964	35		15	32	178	53		313
1964-1965	41		30	28	206	58	79	442
1965-1966	27		45	40	207	55	114	488
1966-1967	30		45	72	231	8	132	518
1967-1968	45	3	39	131	230		146	594
1968-1969	36	7	24	137	245		151	600
1969-1970*	33	11	9	132	262		143	590
1970-1971*	25	7		80	288		141	541

This table denotes awards offered, and differs from Table IV which denotes awards accepted by registered M.I.T. students.
This table does not include data on the continuing National Institutes of Health fellowship and traineeship programs which had their inception in the 1940's.
* Not included in table: 3 NASA International Fellowships, 41 NIH Fellowships and 160 NIH Traineeships for 1970–71.

INSTITUTE RELATIONS

Dean Nyhart begins his report with reference to the extreme contrast between previous academic years and the one just ended. Such wide fluctuations in campus mood, in student use of support services, and student involvement in their educational program present a major challenge to any university. The underlying issue for M.I.T. is to know where we are on the swing, the pendulum, or perhaps, where we are on the slope of the sine curve called "progress." One task over the past two years has been to develop processes, analogous to navigational aids, that will help us know where we have been, where we are, and where we can reasonably expect to proceed in the near future. These questions apply to the entire academic program but have a specific and special urgency in the areas of the Dean for Student Affairs' responsibility, for here, shifts in the students' life styles, in their degree of trust, and in their felt needs directly influence their interaction with the programs discussed in the following pages.

The reports of the various associate and assistant deans and of the Director of Athletics document some of the more striking changes. There was the drop in student activism and the falling away of involvement in the Undergraduate Association. Both of these trends were associated with the rise of "privatism." I mean here simply that students, and many of their faculty, turned inward, their immediate horizons narrowed, and one heard talk about the most pleasing color to paint the room rather than the most effective strategy for revolution. Whether this is for good or ill, or what factors underlie such shifts obviously goes beyond the scope of this report. The important point in this context is that such shifts occurred over a period of months and have had major consequences for both the

short- and long-range planning of those in the Dean's Office concerned with meeting student needs and supporting their concerns. The deans have learned much and responded well to these shifts in climate.

The section of the report on minority students is particularly germane and deserves special mention. The shift here has been slow in coming but has challenged the Institute, and some of its educational tenets as well, to reexamine its collective stereotypes of both minority students and women. Such examination is long overdue, though the exercise is far from easy and certainly not yet ended. We have seen clear evidence that S.A.T. scores alone cannot tell us what we need to know about a prospective student's motivation or his or her persistence or inherent ability to develop say, two years hence. There has been a corresponding awareness of these same issues as departments have begun to widen their search for new faculty from those groups formerly largely excluded from even the most cursory review. These issues are complex, and their resolution will not come from the application of some simple formula. The ambiguity is with us for some time to come, and we will need to learn to live with it, to learn from it.

So, the major theme, underlying all the rest, is change, and the central question is whether we can be responsibly responsive to the fact of change. The symptoms of this change are manifold: the drop in students using commons, the development of coed dorms, the presence of often ignored black students on campus. As we move into this new decade, we will need to develop a range of supports for our students, and for all of us, that may only faintly resemble those that served our students and faculty a decade ago. It is against this background that the reports of the office should be read.

BENSON R. SNYDER

OFFICE OF THE DEAN FOR STUDENT AFFAIRS

The extreme contrast between this year and the 1969-70 year emphasizes three points. First, cycles of campus mood can be very short. Second, we must be responsive to legitimate needs for change on a current or near current basis. Finally, we must devise processes that can continue to work both for continuity *and* change in spite of short cycle swings. During this year, the Dean's Office made considerable progress on meeting or experimenting with needs for current change and on improving processes which lead to long-range change.

The Dean's Office serves both students and faculty. This year, we

increased our support of students in several ways, a move which does not seem to have gone unnoticed by them. At the same time, we have developed policy positions that simultaneously further the traditional emphasis on independence and growth for students, while minimizing our role as a filter between students and faculty. A look at four major concerns of the Office of the Dean for Student Affairs will help to place in perspective some overall issues.

HELPING STUDENTS WITH PROBLEMS During this year, the Dean's Office has improved its capability of helping students through a wider understanding of the structure of helping resources throughout the Institute. We have enlarged our counseling group. Data, in the form of records of our own contacts with students and faculty, analysis of withdrawals through the Office, and student opinions, are being gathered. Members of the Dean's Office have worked with the Campus Patrol to facilitate communication between the Patrol and minority student subgroups. For the first time, faculty and graduate student residents in Institute houses will meet for a three-day workshop before the beginning of the fall 1971 term, to discuss the role of the faculty residence system as a support structure.

Helping is not confined to human resources. This year the Activities Development Board was restructured into a broad funding agency to support small and medium capital needs of student and community activities, and we also found small seed money for several student programs during the year.

THE NATURE OF STUDENTS' ENVIRONMENT The three main areas of the nonacademic physical environment with which the Dean's Office is concerned, housing, athletic, and activities programs, cannot adequately meet the demands made upon them. In response, we are continuing short- and long-range planning in each of these areas. In May the needs of the living environment, especially housing and dining, were reviewed with the Corporation Visiting Committee for Student Affairs. We expect a Visiting Committee review on athletic facilities in the fall and on West Campus activities facilities in the spring. While such long-term planning continues, current change needs, such as voluntary commons or expanded coed living arrangements, must be examined.

THE NATURE OF STUDENTS' RELATIONSHIPS AMONG THEMSELVES AND WITH OTHERS The most important nonphysical aspects of the environment are the relationships students have with each other and with other, particularly older, members of the M.I.T. community. The Dean's Office

has a dual role, first, by providing relationships themselves, and second, by facilitating relationships with faculty and administrators. M.I.T. is fortunate to have an administrative structure that places concern for students in many places, rather than within one office. As a result, a small percentage of students does come into direct contact with much of the Administration. It is the policy of the Dean's Office, whenever possible, to further such direct interaction, minimizing our action as an intermediary whenever possible. Both parties benefit.

There are, of course, times when the Office must be in a filter or value role. The Dean's Office has at times joined with other bodies to act as mediator in times of crisis, and at other times has helped people state assumptions and discuss differences before crisis is reached.

Two incidents are illustrative. The first was the aftermath of the November, 1970, disruption of the Faculty Club, in which the Dean's Office joined with the Discipline Committee to mediate a sanction acceptable to both parties. The second was in response to a student Homophile League request for a city-wide gay mixer. In arriving at its decision to deny the request, the Dean's Office took care to consider the wide-ranging interests of M.I.T.'s diverse community.

CHANGES IN INTERNAL MANAGEMENT The Dean's Office has moved to a program budgeting structure which will enable us to make better use of accounting office data and to permit persons with operating responsibility to use the budgeting process as a planning and evaluative tool.

During the past year Miss Nanette Smith of the University of Rochester and David W. Yohn, minister of the Church of Christ at Dartmouth College, joined the staff as Assistant Deans in the counseling group. Richard Sorenson has become Associate Dean, with program responsibilities for the living environment area. Kenneth C. Browning, formerly of the M.I.T. Housing Office, has joined the Dean's Office as Assistant Dean.

Mr. Jon Hartshorne has replaced Dean Jay C. Hammerness in the Office of the Dean for Student Affairs, and Mrs. Dorothy Bowe has become Assistant Director of Financial Aid.

In the Athletic Department, Mrs. Christine Randall joined the staff as coach of women's field hockey, basketball, and softball, while Mrs. Joan Blackmer accepted a part-time position as dance instructor.

Two housemasters have resigned. Professor Herbert H. Woodson, who served as Master of Burton-Conner for three years, is going to the University of Texas, and Professor Klaus Bieman, Master of McCormick Hall for the past four years, is returning to full-time duties in the Department of Chemistry.

COUNSELING AND ADVISORY SYSTEMS

STUDENT COUNSELING

The portion of the Dean's Office most closely associated with face-to-face, one-to-one counseling of students experienced four major changes during the year.

INCREASED CAPABILITY AND AVAILABILITY The number of deans has increased from three to four, which has considerably increased their availability to students. The four counselors bring a variety of resources to the students — different backgrounds, different counseling styles, and a wide range of ages — and to seek each other's advice, the counseling deans regularly meet together each week. Unfortunately, the increase in personnel has resulted in serious space problems which require early resolution.

REVIEW AND COHERENCE OF POLICIES AND PROCEDURES During the year we reviewed basic counseling policies and procedures in order to achieve coherence among the counselors without moving toward "standardization." As examples, we have extensively reviewed the process of a student's withdrawal from M.I.T. by clarifying information, talking over the process, and making a detailed study of withdrawal patterns, and we have similarly reviewed readmission procedures.

A third policy area under review relates to *in loco parentis* policies. In a society in which norms for young people are rapidly changing, we are trying to understand better the triangular relationship of student, parent, and Institute. Because, in a legal sense, the implied contract is between the student and the university, the Institute must be careful to understand its responsibilities to the student, particularly as the social order increasingly treats its young people as responsible adults, and to understand the changing norms of students rights and privileges. We are trying to understand better what these changes imply for our dealings with both parents and students. It is felt that separation from the university by a student should normally involve some communication with the parents, and we are trying to determine the best means of maximizing the contact between the parents and the student when there is difficulty. In the case of many things that occur to a student at the university, such as poor grades, we are seeking to discover ways by which we can put parents and students in direct relationship to each other, rather than our acting as a mediator between the two.

A related issue which has occupied much thought during this year is that of confidentiality of records. One member of the Office has served

on the Committee on Privacy during its deliberations. Continuing contact with this committee has been helpful.

TIES TO FACULTY AND OTHER COUNSELING RESOURCES There continues to be extensive interaction between the counseling deans and faculty advisors. Advisors call frequently to express concern about the well-being of their advisees, and counseling deans rely heavily upon the insights of faculty members.

Through a series of experimental meetings with six different departments, interaction between the Dean's Office and advisors was also increased on a group basis. Conversations were informal and ranged over a wide variety of topics. We are now assessing these meetings and seeking other forms of interaction between departments and the Office of the Dean for Student Affairs.

The Dean's Office also initiated meetings with the Financial Aid Office. Since the relationships between the two offices tend to be close, it was helpful to have these sessions in order to clarify policies and procedures. We are now holding similar meetings with the Foreign Student Office. Although these have only recently begun, we look forward to a series of discussions in which the continuing cooperation between these two offices may be enhanced and strengthened.

HELP TO SPECIFIC GROUPS OR PROGRAMS The responsibility of the Office to the Committee on Academic Performance, to the program for expanding M.I.T.'s educational opportunities to black and other minority people, and to the undesignated sophomore program continued.

Added to these were involvement in three new areas. The Education Research Center developed an experimental study program during the first term. Two counseling deans became deeply involved with the program during second term, and several students were able to use it to increase the effectiveness of their study time. There seems to be a growing demand for this kind of assistance; we will continue to experiment with the program during the summer term with plans to expand it during the next academic year.

Responding to some of the issues raised during the year by the Student Homophile League's request for a city-wide gay mixer, the counseling deans have become involved with the concerns of homosexuals on our campus. We are prepared to be of help to young men and women who are coping with their sexual identity.

During the year the Office was asked to be a counseling resource for students entering R.O.T.C. programs at the Institute. One of the deans

is now prepared to be of help in both personal and legal counseling to students.

The Visiting Committee of the Office of the Dean for Student Affairs met in November, 1970, to review the various advisory resources available to students at M.I.T. To study these resources in detail, the Committee spoke with students, faculty advisors, housemasters, tutors, and members of the Medical Department, the Dean's Office, and academic committees. The exposure resulted in an expanded understanding of the resources open to students and an alertness to the continuing and constant desire to make available a total advisory capacity of the highest quality. It has become clear to us that we have functioning programs that are flexible and open, and that contain an impressive number of excellent advisory resources, but it is also clear that much work remains to be done, if the total impact of M.I.T.'s advising and counseling resources on the educational experience of its students is to reach its full potential.

FRESHMAN YEAR

Four aspects portray the flexibility and choice that characterize the continually evolving freshman curriculum.

Among the most significant changes was the restructuring of 18.01-18.02, in which Professor Mattuck divided the subjects into six units per term and established a flexible program of recitations and self-paced examinations. Students and advisors alike reacted very favorably to the new format and the instructor regards the changes as successful. The self-paced mode was tried in physics and chemistry and work continues on the development of study guides for additional subjects.

A second change was the further extension of options for meeting General Institute Requirements. These included the new biomedical option in freshman physics, which was chosen by 6 per cent of the freshmen, and the formal addition of a general biology option in meeting the chemistry requirement. The Department of Humanities will increase the number of its options from five to eight, beginning in the fall.

Third, a dramatic growth in the number of available electives and freshman seminars offers freshmen unprecedented opportunities to try different subjects as they define their course and career objectives. Ten years ago there were no freshman seminars and fewer than twenty electives from which freshmen could choose. Last spring there were over 250, not including Harvard or Wellesley cross-registration options. Within the last four years alone, the number of fall term offerings has increased 60 per cent, while the registrations in these subjects has increased almost 30 per cent.

Finally, the introduction of the Independent Activities Period, enthusiastically received by freshmen, upperclassmen, and faculty, provided opportunity for formal and informal work on regular academic subjects, as well as paid employment. According to a C.E.P. survey and two separate questionnaires distributed by the Freshman Advisory Council, most freshmen spent the majority of January in Cambridge. There was less of a tendency for freshmen than for upperclassmen to become involved with special activities, but at least some found their way into interesting projects. While future efforts will be aimed at encouraging freshmen to seek unique opportunities, it is realized that many freshmen will still be adjusting to the academic environment and may benefit more from spending some January time working on the formal curriculum.

These trends are expected to continue next year. The experimental Study Group and the Unified Science Study Program will continue in the fall and will be joined by Concourse, an experimental program of similar scope, in which 30 to 50 freshmen are expected to enroll. The Undergraduate Research Opportunities Program will provide new opportunity for freshmen in M.I.T. laboratories.

A growing problem that freshmen advisors and the Dean's Office share with students is the difficulty in keeping track of and evaluating this great range of offerings. The decreasing intimacy of choice once afforded students and their mentors is a cost borne in order to achieve the current wide selection. The Dean's Office and faculty alike must work to avoid an impersonal, mechanistic approach to choice.

GRADING AND ACADEMIC ACHIEVEMENT Evaluation of freshman pass/fail continued during the year. While a sample of freshmen and upperclassmen showed near unanimity in favor of pass/fail, instructors of freshmen and sophomores had many reservations. A majority of those faculty responding indicated they would like to see pass/fail continued, but a significant percentage favored a variety of changes including, in some cases, a return to the former A-F grading system.

One of the frustrations mentioned by some faculty has been the issue of "maintaining academic standards." The changes in 18.01-18.02 were stimulated in part by this issue, and, interestingly enough, here and in the self-paced subjects, students have generally accepted the concept of high level performance on the unit exams. It seems that pass/fail, *per se*, is not the central factor affecting academic quality and standards.

FRESHMAN ADVISORY COUNCIL During the year improvements were made in several areas of F.A.C.'s responsibility: the program of freshman

advisors and associate advisors, communication among the F.A.C. staff, the Freshman Handbook, and Residence/Orientation Week.

Altogether 165 faculty and staff had one or more advisees, representing a new high for faculty involvement. However, the most significant annual increase in numbers of advisors will occur in the fall, when over 200 faculty and staff will be freshmen advisors. For the first time, these volunteers will be asked to advise no more than their preferred number of freshmen.

Associate advisors numbered 128, as F.A.C. continued to experiment with increasing the effectiveness of this attractive idea. Several associates did outstanding jobs in assuming essentially full responsibility for their advisees.

For the first time, advisees were assigned according to advisors' preferences, which often included non-professional interests. Procedures for advisor changes were also initiated, and by the end of the year about 15 per cent of the class had changed advisors.

Last year the F.A.C. staff met in small, informal groups with over 80 per cent of the advisors and more than half the associates in attendance. These meetings were an important vehicle for the exchange of ideas and opinions, and there was much favorable reaction to recent changes.

The Freshman Handbook has been further improved and continues to be well received by both freshmen and advisors. Under the able coordination of Gregory Chisholm, '73, Residence/Orientation Week was successfully adapted to the new calendar. In both of these areas, student initiative and contribution continued to be important.

Several areas need special emphasis during the coming year, in particular, further development of year-long course orientation programs at the department level; better focus on course and career selection; a decision on the future of the associate advisors' program; and efforts to measure the effect of recent changes on the advisee-advisor relationship.

Next year the F.A.C. Office will assume responsibility for administration of the Undergraduate Seminar Program. Because this program shares with the F.A.C. the goal of improved student-faculty interaction, efforts will be made to find new ways in which the two programs may be mutually supportive.

The F.A.C. looks forward to the report of the Rogers Task Force which will concern itself in part with the advisory role in the first two years.

UNDERGRADUATE MINORITY STUDENTS

For the second consecutive year, the Office of the Dean for Student Affairs has participated intimately in M.I.T.'s efforts to attract and enroll

sizable numbers of blacks, Puerto Ricans, Mexican-Americans and American Indians, and to afford them meaningful and enjoyable educational opportunities. Under the supervision of the Task Force on Educational Opportunity, these efforts have centered upon recruitment programs, admission criteria, financial aid, summer transitional programs, and academic year counseling and tutoring supports.

RECRUITMENT AND PROJECT INTERPHASE Intensive mailings to high schools, guidance counselors, and community agencies, and advertisements, use of referral agencies, and selected school visits and college guidance conferences yielded 321 black applicants for the class entering in 1970.

Forty-five of the blacks along with eight other persons offered admission were invited to Project Interphase, a summer transitional program, first offered in 1969. The seven-week program retained its objectives of assisting students in strengthening their verbal and mathematical skills required for the first year subjects at M.I.T., permitting the students to develop gradually their individual adaptations to the Institute's academic and social nature, providing an introduction to the M.I.T. and Greater Boston communities before the fall term pressures, and enabling M.I.T.'s staff to learn of the students' strengths and needs early enough to supply timely help. Classes were offered in calculus, physics and humanities. Satisfactory performances in these three subjects provided each student with a block of 18 units of elective credit.

The teaching of calculus in Project Interphase was a major change from the 1969 program, whose mathematics classes limited their coverage to review and expansion of high school materials. By also studying calculus material required for completion of the first two 18.01 examinations, the students accrued a sense of accomplishment of "authentic" M.I.T. work not present at the end of the 1969 classes. The physics classes reviewed materials needed as background for M.I.T. freshman physics and familiarized the students with the fundamental concepts, techniques and styles of 8.01. As in the previous summer, the humanities classes were organized around issues presented by autobiographies of people from a variety of racial, economic, social and religious backgrounds and around comparisons with issues before today's college youth.

On the final two days of the program, the staff made individual recommendations to the students about subject choices and academic loads for the fall term and provided Dean Bishop with evaluations of each student. With the exception of one student who did inadequate work in physics, all students performed satisfactorily in calculus, physics and humanities.

Thirty-eight Interphase students successfully completed their first year at M.I.T. without any dropouts, second warnings, negotiated withdrawals, or disqualifications. One white student participant decided in September to transfer to a college near his hometown. This academic record for the 1970 Project Interphase students was a marked improvement over that of the 1969 group.

SUPPORTIVE HELP In addition to its role in the admissions process and in the planning and coordination of Project Interphase, the Dean for Student Affairs Office provided a variety of supports during the year for the black and former Project Interphase students. Where appropriate, Dean Bishop conferred with freshmen advisors about the Interphase staff's recommendations for each student. During the fall term, Deans Bishop and Smith sought individual conferences with each of the black freshmen to acquaint them with the resources available at M.I.T. to answer their questions and to determine where and how they could be assisted.

Throughout the year, meetings with individual students or groups of students over meals in the campus dining rooms were held. Dean Smith prepared dinners for black freshmen at her apartment. Where the mid-term evaluation forms or direct reports from instructors, advisors, or tutors gave clues of a student's undergoing difficulties, he was contacted and afforded chances to discuss his situation with a dean.

The Freshman Advisory Council's obtaining copies of the evaluation forms directly from the instructors greatly assisted and speeded up these follow-ups. During the second term, Dean Smith put black freshmen with academic problems in contact with other black students, staff, and faculty for tutoring. She also helped some students with improvement of their study habits.

In the spring term Dean Bishop asked advisors of those second-year students who had previously experienced academic difficulties to evaluate their advisees mid-term performances and point out any areas of needed aid. These communications stimulated most of the advisors to confer directly with the students or their instructors and led, in some instances, to the students' receiving assistance that likely would not have been offered until the end of the term.

With financial support from M.I.T.'s work-study funds, the Black Student Union developed and carried out a tutoring program. Based in the B.S.U. lounge in Walker Memorial, this service was frequently used by black freshmen and sophomores seeking assistance with subjects in physics, calculus, chemistry, computer science and electrical engineering.

Both the graduate and undergraduate students who worked in this program, often as volunteers, are to be commended for their initiative, effectiveness, and diligence.

ACADEMIC PERFORMANCE The achievement of the black students of '73 and '74 exceeded the levels predicted for them by traditionally employed selection factors. Of the 53 blacks who entered in 1969, 26 (49 per cent) have received satisfactory grades for each of the four completed terms. Eight (15 per cent) are in more or less satisfactory situations but received warnings during one of the four terms. The records of the other 19 (36 per cent) have caused continuing concerns. Of these 19, one was disqualified, seven negotiated withdrawals and five were warned at least twice by the C.A.P. Seven (13 per cent) of the 53 black students who entered in 1969 voluntarily left M.I.T. with satisfactory records.

The personal costs to students who fail at M.I.T. are too great to permit a continuation of the above numbers of repeated warnings, dropouts, and failures. Those students who must leave M.I.T. lose at least a year in their educational schedules, face very limited opportunities for admission to other colleges, and usually are unable to obtain financial aid at these few schools that will admit them as transfer students. This is almost a complete reversal of the situation during their final term in high school. Though difficult to assess completely, the psychological damages caused by the failure are usually severe and long-lived. These students are not the only persons affected. Their student colleagues, relatives, neighbors, friends, and former high school counselors and teachers often do not know or do not understand the causes of their failures and subsequently lay undue blame upon the students, M.I.T., or themselves. For instance, the high incidence of poor academic achievements upon the black sophomores lowered the confidence of even those black sophomores who were performing well, produced worries among the black freshmen, and led to fault-finding and guilt among both undergraduate and graduate black students. Some non-students were similarly affected.

On the basis of two terms of data, the black freshmen this year fared academically better than did their counterparts a year earlier. By June, 1971, only one black of '74 had withdrawn voluntarily and only one had to accept a negotiated withdrawal. A total of 11 (19 per cent) of the 59 students who completed both terms received academic sanctions.

The stronger academic character of the blacks of '74 was also supported by observations of the Project Interphase staff, some instructors of freshman subjects, tutors and some advisors. A good deal of the academic differences between the blacks of '73 or '74 can be attributed

to the "pioneering" position which the blacks of '73, the first large entering group, had to endure. Another factor was the greater consideration given to motivation, adaptability, and perseverance during the admission process of 1970 than in 1969.

The Faculty Club incident of last fall and actions related to it left deep and widely mixed feelings within the M.I.T. community. During conferences with the Dean's Office, many of the students involved spoke of group cohesion, increased awareness of the subtleties of racism, the difficulties of group dynamics, and the complexities, advantages, and risks of seeking institutional changes through active involvement, as well as of fear, confusion, defeat, disillusion, anger, and mistrust toward differing persons and groups at M.I.T. The effects of this matter have yet to emerge fully.

During the spring, M.I.T. received final applications from 285 black students and offered admission to 76. Twenty-five blacks and ten nonblacks started the third Project Interphase which began in June, and another 21 black freshmen are expected to enroll in September. However, the goal of 100 entering black freshmen has not been reached and the number of entering blacks is expected to remain between 40 and 70 for at least the next two classes.

LOOKING AHEAD The Task Force on Educational Opportunity and the groups with which it has worked in order to improve the opportunities for minority students have successfully organized and carried out recruitment and admission processes, financial aid processes, an ongoing transitional program, and guidelines for establishing black-related subjects, counseling, tutoring, and other supports.

Effective recruitment programs for Puerto Ricans and Mexican-Americans are likely to be instituted in 1971-72. It is doubtful if any substantial success will be made in attracting American Indians. Steps must be taken to assure that these programs are not cut back and rendered impotent by the growing shortage of financial aid funds. For minority students, attendance is pivotal on the availability of adequate financial aid.

Since December, 1968, the Institute has discussed and studied periodically the issues related to various proposed Afro-American centers. It would be helpful if these discussions were brought closer to where decisions could be made.

The fiscal year has ended with disappointing reports from the 23 M.I.T. departments that not a single new black faculty member has been appointed for 1971-72. The continued paucity of full-time black faculty members is the most serious failure of the Institute's entire equal oppor-

tunity program. Unless the black faculty increases, students — black and white — can never receive maximum benefit from their M.I.T. experience. Whatever else is done by M.I.T., the failure to increase the black faculty will cause concerns to persist about the Institute's commitment, sincerity, and priorities and will generate a prevailing spirit of tenuousness, possible neglect, and anticipated abandonment.

THE WOMEN STUDENTS

The most significant phenomena involving the women students are the psychological and attitudinal changes brought about by the sheer increase in their numbers and the closely-related decision this year that the capacity of McCormick Hall no longer limit the number of women accepted, but instead that, within each entering class, admission of women and men be based on the same criteria.

The 130 freshman women in the entering class of 1975 constitute more than 10 per cent of the class. The contrast with the 39 women in the entering class of 1967, the first to spend four years in McCormick Hall, is striking. The impact of this change is hard to estimate.

The recent increases in the number of women students has made possible their greater participation in team sports. This year women's teams in field hockey, basketball, and softball inaugurated intercollegiate competition. A high point in the history of M.I.T. women was reached when Kathy Jones '71 and Maria Bozzuto '73, members of the Women's Varsity Sailing Team, received M.I.T.'s highest athletic award, the Straight T.

The establishment of a women's entry in the new Burton-Conner House symbolizes, in a different way, the current place of undergraduate women at M.I.T. Women are now members of six living groups.

Looking to the future, one can see the primary needs of female students — along with outlook and spirit — have changed greatly. The initial challenges of bringing women "into the system," which involved operational aspects of encouraging development of a tradition and style primarily within McCormick Hall, have faded. So has the competition for admission, extremely severe, which resulted often in a kind of "fierceness" in outlook that affected women's approach to and view of life at the Institute.

Their attention is focused not only on their place as women at M.I.T., but also in the professions and the world. The primary needs are no longer those of a small minority who seek good places to live and ways to become involved. Most women have long-range career goals in fields that now and for years to come will be predominantly masculine: medicine, the natural sciences, engineering, architecture, economics, and busi-

ness management. Many look forward to marriage and a family. The most difficult and challenging question for which they seek an answer is whether or not to submerge the ability to master an exciting field and an important job in exchange for marriage and a family or if possible do a good job at both.

To answer this question is difficult anywhere, but it is doubly hard to answer at M.I.T., where the number of women holding professional jobs is so small. A major effort of the coming year will be to develop ways for women students to become acquainted with the range of diverse and talented women on the faculty and staff and to lend some visibility to female professionals.

The freshman seminar, "Women in the Professions," to be given by Dr. Carola Eisenberg in September, is one example of the sort of activity that can be fostered. Graduate women, in particular, stand to profit from getting to know women post-doctorals and faculty. Although there is a rather large amount of information on the history and progress of women undergraduates at M.I.T., almost none is available about female graduate students. While the decentralization of records is understandable because of the nature and organization of the Graduate School, both the growing concern for the status of women in universities and professions and the intrinsic value of having the facts at hand strongly indicate that more information about female graduate students should be gathered. A second major goal of this office during the coming year is to work with the Office of the Dean of the Graduate School to establish ways and means to accumulate data on academic performance, fields of concentration, placement information, and postgraduate professional progress of women graduate students.

The Women's Liberation Movement has led us all to reevaluate the meaning of the word liberated, particularly as it applies in the context of education and the aspirations of young women and men. Both seek to establish their own identities and to find their own paths to "success." Men and women may have some different educational needs and may have some unshared assumptions about how to achieve their goals. As the number of women students increases, it is essential that M.I.T. be sensitive to their special needs and respond to them.

PREMEDICAL ADVISORY PROGRAM

The number of M.I.T. students applying for admission to medical school has tripled in the past five years. The energies of the Premedical Advisory Program this year have been consumed by understanding this phenomenon, by coping with its present impact, and by altering the program's structure to meet increasing future needs.

The appearance of two new subgroups among premedical students further complicates the advisory task. Not only has the number of highly qualified applicants to medical school greatly increased, but a totally new group of students, disillusioned with pure science and engineering but attracted by the idealistic and service aspect of medicine and to the idea of applying medical knowledge to social problems, has appeared. Many will find medicine to be their chosen field. A significant number, however, are not sufficiently knowledgeable or motivated to have a chance of acceptance by a medical school. These students need listening ears and wise counseling, not assistance in applying for admission to medical school.

If one is to be realistic, another new category is to be expected both this year and in the foreseeable future. This group will include very highly qualified, well-prepared, and mature individuals who will be rejected because space for them in medical schools simply does not exist. These students will deserve M.I.T.'s best help in order to channel their interests and energies into useful careers and away from bitterness born of their frustrated efforts in gaining admission to medical school.

During the year, the needs of undergraduates, graduate students, and alumni for advice and assistance far surpassed the resources provided, which were essentially those of the Premedical Advisory Program, established in 1967 as a part-time activity of the Dean's Office. To meet these needs interim actions were taken and active consideration is being given to a satisfactory long-term resolution of the advisory problem. Membership of the Premedical Committee is being increased. Each member has agreed to accept up to ten students and to become sufficiently well acquainted with each to prepare a letter of reference or commentary which would serve as the "official word" to medical schools from M.I.T.'s Premedical Advisory Program. The Premedical Office has converted itself primarily to an interviewing, advisor-assignment center, an information exchange, and a central collection spot for letters of reference from faculty members and from premedical advisors.

The goal of the Premedical Advisory Program is to help students decide for themselves whether medicine should be their profession, and if so, provide information and assistance in their preparation of applications for admission to medical school. Because of the wide variety of personalities involved and the individual nature of the several conversations needed for developing an understanding of anyone's career goals, the Advisory Office must be perceived as a welcoming and friendly place, where an even-handed attitude prevails. As much assistance must be given those whose applications probably have little or no chance of success, as to those who already have demonstrated remark-

able initiative and leadership in medical fields or in social service and whose grades are outstanding. Not to do so is to obstruct seriously the rejected student's opportunity to educate himself through the application process, the interviews, and the school visits, and thereby to gain increased understanding of himself, his goals, and his most promising course of action.

THE FOREIGN STUDY OFFICE

Today's increasingly sophisticated M.I.T. student is becoming more conscious of the interest in and benefit from a period of study in a different cultural or educational environment. The Foreign Study Advisor advises at three distinct levels of possible study abroad: post-doctoral, post-baccalaureate, and undergraduate (primarily Junior Year Abroad). At the post-doctoral level his principal role is to suggest appropriate potential assisting agencies with which the student is to deal directly. At the post-baccalaureate level, he assists the student in preparing applications for foreign study grants from such agencies as Fulbright-Hays, Marshall, Churchill, and others offering financial assistance. He, in collaboration with the Foreign Scholarship Committee, reviews these applications, interviews the applicants, and provides an evaluation of each to the sponsoring agency.

At the undergraduate level, counseling the prospective Junior Year Abroad student constitutes the Foreign Study Advisor's largest activity. After mutual exploration of interests and qualifications, 80 to 90 per cent of the students seen decide not to undertake a junior year away. For the remaining 10 to 20 per cent, the Foreign Study Advisory encourages and guides toward admission to a program or institution abroad and toward negotiations for assuring that the work done away can be given serious consideration for credit toward an M.I.T. degree.

During the past year many students showed an interest in the Domestic Year Away program which was approved by the faculty in April, 1970, for a three-year trial period. For these students, either of two purposes is served: to utilize specialized facilities or programs not available at M.I.T. or one of its cross-registered institutions, or to experience the major change in environment provided by a full university or liberal arts college community. Next year nine students will be involved in the domestic year away.

Those returning from a junior year away have, with very few exceptions, rated the experience very highly as a contribution to their total growth and development, as well as an excellent experience in their formal education.

For our particular student body, experience strongly supports the

policy of leaving the responsibility with each student for choosing his own plan and kind of program, subject only to making his official registration as an M.I.T. student, while he is on leave, contingent upon obtaining formal approval of his plans from his major department, from the Department of Foreign Literatures and Linguistics where foreign language competence is pertinent, and from any others, such as Humanities, to which he wishes to submit his work abroad for M.I.T. credit.

During the past year, the Foreign Study Office increased its campus publicity and included such communications as memoranda to Department Headquarters, faculty, and students; announcements (paid and unpaid) in 30 issues of *The Tech;* operation of a booth in the main corridor on the Experiment in International Living; slide show announcements and bulletin board publicity in the main corridor; and a feature article in *The Tech* on M.I.T. resources for studying abroad.

THE LIVING ENVIRONMENT

This year was one of continued change and progress within both the program and facilities of the total student residential system.

PROGRAM

Progress within the program was typified by strengthening of the housemaster-tutor system, by record numbers of pledging in the fraternity system, by a decision for voluntary commons, and by expansion, after a successful first year of on-campus coed living arrangements. The major problems are a decline in student participation in governance of their living environment, continuing soaring costs, and the necessity of estimating now what future life-styles students will seek.

The housemaster-tutor program has undergone review this year, and a number of steps have been taken to strengthen the system. The tutor selection process was further decentralized; in each house students worked closely with faculty residents to reach joint and mutually acceptable conclusions on candidates for graduate resident tutor positions. The performance of each current graduate resident was reviewed carefully at the house level. The titles "housemaster," "senior tutor," and "tutor" have been replaced by "faculty and graduate residents." The senior faculty resident (formerly housemaster) will continue to serve in the senior coordinating role. Preceding the arrival of the students in the fall, there will be for the first time a workshop for all faculty and graduate residents and their spouses. The three-day program will attempt to raise the residents' awareness of the resources within M.I.T. available to them and to their students. The Dean's Office is also formulating a

continuing "in-service" training program aimed primarily at the graduate residents throughout the academic year.

M.I.T.'s fraternity program continues to thrive. Last fall, a record 404 freshmen pledged fraternities, topping the 1968 record by 30 men. Possibly more important than the number pledged is the estimated 800 freshmen who at least considered the fraternity option in the process of selecting a living group. An important factor is the cooperation between the fraternities and the Institute houses that has been fostered in this effort.

The decision to enter into a one-year experiment in voluntary commons beginning in the fall is a milestone in the time-consuming and difficult area of food service. Voluntary commons will exist in Baker, McCormick, and MacGregor, and is essentially being underwritten by a fee charged to all residents of these houses. The residents of Ashdown, East Campus, and Senior House will also be, in part, underwriting the operation of Ashdown and Walker Memorial. The total scope and detail of this move reflect a definite program change, but they also indicate an attempt to bring the dining service to a financial break even point. We will be monitoring the results of these changes with great care. We are aware that we may be faced with the difficult decision to close down more individual house dining halls.

In the fall, two additional living options will be opened to undergraduate women. One entry of approximately 35 spaces in Burton-Conner will be opened to women. This less-than-totally-integrated space will give to all residents of the house a new opportunity for a kind of limited coeducational arrangement. Second, Russian House will have four out of its 16 spaces available to women. These developments are consistent with the aim of providing equal opportunities to women students in all phases of their education, and arise from the positive experience of this year, in which East Campus, Senior House, Sigma Nu and Delta Psi (No. 6 Club) all completed their first year of coed living. The M.I.T. Student House concluded its second year. One of the most interesting and consistent observations by the Dean's Office and by the students themselves is that a move to coed living in a living group does *not* change the basic character of that group.

This past year has seen a major dip in the activity of and interest in the Interfraternity Conference and the Dormitory Council. Both have sought unsuccessfully to find appropriate and important reasons for their existence. In the case of the Dormitory Council, the trend resulted in its more or less ceasing to function for most of the year. The I.F.C. met regularly, but without purpose, and almost always in a sense of introspection that became counter-productive.

The most remarkable conclusion has been that both groups, at the time of their annual turnover of membership and officers, faced openly the question of whether or not they should continue to exist. In both cases, the new group reached nearly unanimous consensus that continued and renewed operation was strongly in their best interest. The new leadership in both organizations reflects this posture and gives promise for a major revival.

Within both the Institute houses and the fraternities, costs to students are increasing rapidly. This is a continuing problem for both students and the Institute. In both areas, operating budgets are cut very closely. More and more services are being reduced, and in many instances are now at minimal levels. This topic is one of particular interest to the Dormitory Council, and the Dean's Office expects to be working closely with them and with the Housing Office to monitor costs and services, while exploring new means to hold the cost to each student at a manageable level.

Finally, the primary questions of life-style of future students present problems which must be faced today: the potential of the dramatic flight from campus housing experienced at other universities, the necessity of minimizing costs, the desirability in some students' eyes to live in a "neighborhood" environment rather than a cloister. These subjects will be under the scrutiny of a task force.

FACILITIES

An increase in our capacity to house students on campus, a new fraternity, and the start of still additional facilities are major accomplishments of the year, even while attention is turned toward resolution of needs for renewal of facilities and meeting further housing needs in the years ahead.

In September, MacGregor House opened its doors to 324 undergraduate men and 11 faculty and graduate residents. The house reflects M.I.T.'s first carefully thought out and designed undergraduate facility since Baker House and grew out of the 1963 Interim Housing Report of the Committee on Student Environment. The first year's experience with the building has been a positive one, in spite of the fact that the building was complete neither when it opened nor at any time during the year. As many of the problems are worked out and finishing touches done, a much better experience in the house may be expected in the coming year. The consistent talent and energy of the two faculty residents and their families and the nine graduate residents were very significant in molding the character of this first year, and provided visible support for the collegiate house model of which MacGregor is the prototype.

As MacGregor became available, Burton-Conner was gutted and its major renovation begun in June, 1970. The house is scheduled to be completed by August. The former house capacity of 542 is being reduced to 350, in order to reflect the same program and quality found in MacGregor House.

Many people predict that Burton-Conner will quickly become our premier undergraduate facility, in terms both of design and of a new program option. These advocates cite the reuniting of the two units of "Burton-in-exile," Hamilton House and Medford; of adding residents of Random Hall and Russian House; of bringing together approximately 30 undergraduate women from McCormick Hall to make a third co-educational Institute house; and of making available full kitchen facilities in all suites, but without a central dining hall.

During this past spring, the variety of student constituents that will make up Burton-Conner has worked closely and well together with the Dean's Office and the Housing Office. The students have had many difficult problems to sort through, particularly in terms of their own governance. These groups, and the "Client Team," in its continued excellent work with the Housing and Dining Office and the architects, represent tangible examples of students and staff working together in a positive and creative way.

Construction began on Westgate II, adjacent to the Westgate married student complex, with occupancy scheduled for September, 1972. This facility will house approximately 400 graduate students.

In the fraternity system, Pi Kappa Alpha acquired in October a permanent house at 69 Chestnut Street in Cambridge. This facility will eventually house close to 40 men and is our first Cambridge house not immediately adjacent to M.I.T. property. The fine effort made in dealing with a variety of Cambridge government and community agencies in the delicate process of acquiring this facility provided the chapter members a significant growing experience.

Two major problems parallel in importance the achievement represented by these increases in ability to provide housing of the highest quality to more M.I.T. students. First, renewal is desperately needed in the older facilities, particularly in Ashdown House and Bexley Hall where the basic systems of the houses are inadequate and badly worn. Senior House, East Campus, and Baker House are also in need of renewal. A proposed thorough review and cost analysis of renewal for Ashdown House and Bexley Hall reflect the critical priority of this concern.

Renewal of a different sort, embodied in the Fraternities Collaborative effort, continues to provide frustration for all concerned. Only two of

the original five fraternities have made final and total commitments to the project. The process of trying to interest other houses has not met with success. At the same time, problems of site, financing and the uncertainties of fraternity commitments have proved difficult factors in attempting to reach consensus within the M.I.T. administration. It is now prepared to offer a potential solution to the two committed houses that will meet their needs and provide the living environment with a beginning in renewal of M.I.T.'s independent residences.

In addition to renewal, a more difficult question is the projected need for added capacity in the years ahead. Under our current assumptions of undergraduate housing, which include a stable undergraduate male enrollment and a growing undergraduate female enrollment, we will face a major deficit in available on-campus undergraduate housing in September, 1975. MacGregor II, which was shelved in the fall of 1969, anticipated and could have met this need. A task force is in the formative stages of coping with the question of new capacity and the form it should take.

STUDENT AND COMMUNITY ACTIVITIES

Student and community activities presented a paradox this year, perhaps because of the swiftness of short-cycle phenomenon on campus. Amidst general apathy, in which many activities complained of a loss of student participation and interest, other activities flourished. In the middle of these short-cycle program tremors, the inadequacies of our facilities stood out. The Dean's Office during the past year worked on revision of basic processes and policies and articulated a need for an indepth, long-term review of extracurricular life at M.I.T. and its necessary support facilities.

The program shifts were marked. Those traditional activities which relied on a hierarchy of participation, beginning at the bottom and working through to the top, frequently found a shortage of participants. The newspapers, many aspects of student government, and some of the service organizations can be classified in this category. So could the religious activities, the number of regularly scheduled services declining to 408 from the prior year's total of 581. Following a year of a record high, weddings saw their largest percentage of decline in the decade and a half of the chapel's existence.

However, activities offering a higher degree of personal involvement or experience continued to add participants. In this category were the Student Art Association, the Outing Club, Folkdance Group, and the Tech Squares. The same interest in personal involvement was reflected in M.I.T.'s largest single sustained audience response. It was accorded

to the series of Human Sexuality Lectures, jointly sponsored by an *ad hoc* student committee and the Lecture Series Committee, with the assistance of Drs. Clark and Eisenberg of the medical staff. A new individuality might also account for the continued and very rapid increase in new activities, estimated by students to be at one a month. Among the new activities were the Unicycle Club, the M.I.T. Dance Workshop Club, and the M.I.T. Classical Guitar Society. Signs of a revival of traditional activity might be seen in the second successful year of *Kaleidoscope*, the continued success of the Pot Luck Coffee House, and the whimsical but spirited Easter Egg Hunt sponsored by the Class of 1974.

Within this very mixed picture, the Dean's Office concentrated on a revision of operating structures and policies. In response to a long-standing plea of the Music Group, that interest's budgets were finally reduced from five to one and consolidated under the Humanities Group, accompanied by reasonable protections for continued student innovation and informal interest.

Finally, the operations of Talbot House were explicitly placed on a self-sustaining basis, a fact which had been the case operationally for the past two years.

Such program shifts pose the question of stability of the current extracurricular program. But whatever the form that specific activities take, it is fairly clear to the Dean's Office that activities in some form are likely to continue and grow. What is needed is a new assessment of the activities field, to ask what is currently contributing to student growth and development and whether our facilities can adequately support student activities. This kind of examination will be the subject of increasing attention during the coming year, and this summer research designed to gather initial data required for assessment will begin.

STUDENT SELF-GOVERNANCE AND PARTICIPATION IN INSTITUTE GOVERNANCE

In supporting the processes of student governance and the participation by students in Institute governance this year, the Dean's Office has emphasized two points. First, the Office has tried, wherever possible, to support the leadership. Second, it has tried to make more visible the breadth of student governance as it exists throughout the Institute, involving perhaps 800 students.

The process of working through the leadership has meant making sure that the Dean's Office turns to those students who have been elected or otherwise given authority by their fellow students. It has also meant both this Office and the students taking sufficient time to work through the superficial levels of argument, whether the issue is a homophile mixer re-

quest, student responsibility for maintaining the bulletin boards in Institute hallways, or the recall and instruction by the General Assembly of students nominated to faculty committees. It has meant the building of involvement and trust on both sides. It has been a slow process.

Students, faculty, and administration alike have also been rather slow in awakening to the impact around which the second point is centered. Student governance decisions involve an estimated 600 to 800 posts, including the residences, the activity and athletic interests, the more central major components of the Undergraduate Association, the Graduate Student Council, and positions on Institute faculty committees, task forces, and *ad hoc* groups. Today, more than ever before, student governance involves a far wider range than the tight core of 20 or 30 sitting now amongst the regular attendants of the General Assembly. To understand the importance of this change, one must examine the course of undergraduate government over the last three years.

In short, the new General Assembly, as a legislative, open-participation function, has not included the operational apparatus necessary to provide for the entire range of the governance function. Consequently, the broad effort of governance has shifted to students' participation on various faculty standing committees, presidential task forces, study groups, and boards, and to a new birth of autonomy on the part of the standing committees of the Undergraduate Association — Finance Board, Student Center Committee, Nominating Committee, and the Association of Student Activities.

If the first aspect of the student power revolution has failed, the second aspect, the actual spreading of student decision-making power, has expanded beyond the realization of most members of the M.I.T. community.

Meanwhile, at the graduate level, the Graduate Student Council continues to give major priority to the placing of graduate students on Institute boards, task forces, and committees. At present, there are 41 graduate students serving on 29 agencies of governance and planning. The budget allocations of the Council reflect a larger percentage of total funding to provide support for residential, departmental, interest activities, and nationality groups than formerly. This is interpreted as a continuing trend toward decentralization in programming.

The Dean's Office looks forward this coming year to continuing to work with the leadership and to continuing the process of sustaining the foundations of strong student government on campus.

ATHLETICS

This year will be remembered by staff and students closest to the operation of the M.I.T. athletic program as a year of re-evaluation of program

goals in all facets of the Institute's program in athletics and recreation; innovation and diversity in the planning and implementation of a program which will be responsive to constantly changing students' values relating to their interests and participation in non-academic affairs and activities; an expanded program of athletics for M.I.T. women; National Collegiate Athletic Association recognition of M.I.T.'s intercollegiate program as the most inclusive in the nation — 22 varsity sports; a resurgence of general student participation at all levels of the program; programming constraints across the board due to budget cutbacks; and facility limitations which accompany an athletic plant that is no longer capable of meeting the requirements of the M.I.T. community of the 1970's.

The most critical issue confronting the Athletics Department continues to be capital funding for major upgrading and expanding of facilities to accommodate the M.I.T. community. This issue is compounded as the Institute moves forward with the construction of additional on-campus residences for undergraduate and graduate students. Further, there is increased awareness among students and staff of the relationship between physical fitness and excellent health as adjuncts toward career success and general well-being. The greatest need is for those facilities which will provide for informal, small-group recreation during the popular hours at the close of the workday: a second swimming pool, more tennis and squash courts, an enclosed ice skating rink, and expanded indoor athletic facilities for all-weather use. A report of an Athletic Facilities Planning Committee, charged with ascertaining facility needs through 1985, is expected early this summer. It will serve as a basis for schematics to give visibility to plant expansion requirements within the existing land allocations to athletics on the West Campus.

PROGRAM HIGHLIGHTS FOR THE YEAR

PHYSICAL EDUCATION There were a total of 3,869 registrations in 57 courses during the year, including 914 registrations for no credit. In addition there was a capacity registration of 251 students in 11 courses during Independent Activities Period.

New courses this year in sculling (recreational rowing), karate, trampoline, and modern dance increased to 57 the number of courses offered. The emphasis continues to be on quality instruction in small classes, so that all students may find a recreative interest to pursue throughout life.

To bring physical education in line with other requirements at the Institute, advanced placement will be offered. An Appeals Board has been established to consider student requests for waiver of the physical education requirement.

INTERCOLLEGIATE ATHLETICS M.I.T. was named by the National Collegiate Athletic Association as sponsoring the most inclusive intercollegiate program in the nation.

This year, slightly over 650 male undergraduates participated in 459 intercollegiate varsity, junior varsity, and freshmen contests. The fact that the M.I.T. varsity teams compiled a record of 135 wins, 114 losses and 3 ties in 252 varsity events speaks for the fact that our teams — our students — can and do compete favorably!

Water polo was officially recognized as a varsity sport.

There has been a great deal of soul-searching this year among coaches and students, within the auspices of the Athletic Board, which has been directed toward adjusting to constantly changing students' values, with particular regard to the values associated with varsity athletics.

There has been general agreement on the following:

Coaches must *earn* the respect of their squad members; students must find rewards and values in competitive athletics which will favorably balance the pressures and forces working against commitment; winning, in its broadest sense of optimal performance, is a source of enjoyment and ranks among the foremost goals; and coaches must find ways to inculcate joy and a sense of achievement.

Intramural athletics continue to attract the largest participation within the scope of the M.I.T. athletic program.

The Intramural Council was presented a Stewart Award at the 1971 Awards Convocation for "outstanding contributions to extracurricular life at M.I.T." No small part of this impact on student life has been the ability of the student leadership within the IM Council, including representatives from McCormick Hall, to integrate the participation of women in intramurals, which has traditionally been a men's program.

Program innovations included a co-ed basketball league, which operated most successfully at the close of the regular IM basketball season. A series of very successful intramural events was held during Independent Activities Period. All eligibility rules were dropped and students participated for sheer pleasure and recreation rather than in competition developed around living group affiliations.

Severe constraints on the growth of intramural athletics existed because of budget cutbacks, particularly as hours were shortened at the ice rink, the swimming pool, and the du Pont Athletic Center.

CLUB ATHLETICS Club athletics, as apart from the varsity program, is characterized as informal and unrestricted by eligibility rules, and is student-administered. Graduate students, some teaching staff, and undergraduates often band together to organize competition in their

special interests, for which there is generally no counterpart among the 22 varsity sports. The Department of Athletics makes available field facilities, assists with essential equipment, and provides a limited subsidy for special events.

Activity varies within each club, depending on current leadership. The Scuba Club is a good example of an extremely active club, whose activity in recent years has paralleled the increased interest at M.I.T. in oceanography.

Clubs Active in 1970-71

	Roster		*Roster*
Badminton	14	Karate	45
Cricket	16	Rugby — 2 clubs	50
Graduate Crew	12	Scuba	35
Graduate Soccer	25	Weight Lifting	15
Ice Hockey	35	White Water	35
Judo	40		322

WOMEN'S ATHLETICS Representatives of McCormick Hall now participate in the affairs of the Intramural Council and the Athletic Board. The women's sailing team was accorded varsity status this year.

The women's athletic program continues to grow in direct proportion to the increasing number of undergraduate women being accepted for admission to the Institute and adequate space for women's athletics is a major problem, particularly for indoor activities.

CASUAL RECREATION FOR STUDENTS AND THE M.I.T. COMMUNITY The annual sale of athletic cards indicates that about two-thirds of the students and a sizeable number of faculty, staff, and employees are active in some phase of organized or informal sports.

Although casual recreation for all students and the M.I.T. community is one of the prime objectives of the Institute's athletic program, the use of the athletic plant by the "casual" participant is necessarily limited to off-peak hours, when there is no conflict with priority commitment to intercollegiate and intramural athletics. Because most of our facilities are committed to the formal undergraduate program during the popular hours between 4:00 and 7:00 p.m., the casual user is obliged to plan his recreation at noon or return at what is often an inconvenient time in the evening.

Evidence of the interest in general recreation within the M.I.T. community is the response to existing programs in jogging, women's conditioning, faculty-staff tennis and squash competitions, summer tennis instruction, swimming and ice skating classes for faculty-staff children, family swim nights, and noon-hour and twilight softball.

CAMBRIDGE COMMUNITY RELATIONS We continue to extend the use of the athletic facilities to Cambridge community groups whenever there is no conflict with commitments to M.I.T. students, particularly during semester and summer recess periods. Recognition of our efforts to assist our neighbors has been well publicized in the local press.

VICE PRESIDENT, ADMINISTRATION AND PERSONNEL

If there is a common thread which runs through the administrative office reports which follow, it is the impact of national and institutional financial austerity on their primary roles. These are the reports of the M.I.T. offices concerned with placement, facilities planning, admissions, student financial aid, and personnel relations. It may be useful to examine this impact, not as cause for alarm, although measures in response are called for, but to depict the dimensions of the interrelationships within the institution and between the institution and society.

The past year was not a good one for the economy nor for national expenditures on research and development. It was also a difficult year financially for higher education. For M.I.T. the situation was, in the words of the then President-elect, "serious, but not critical."

The national economic picture and particularly R&D expenditures were mirrored directly in the work of the M.I.T. Placement Office. The report of Robert Weatherall, Director of that office, records a decline by 25 per cent of the firms and agencies recruiting at M.I.T., with most of those having many fewer jobs to offer. This decline limited the employment opportunities for all graduating students from bachelor degree holders to the Ph.D.'s. Mr. Weatherall reports a similar experience in alumni placement. M.I.T. has for many years sought to be helpful to its alumni seeking relocation. In the past, this has principally meant transfer to better positions. In the year just past, the number of alumni registering with the Placement Office increased by a third to nearly 1,000, with 90 per cent of those either out of work or expecting to be soon. At the same time, the number of jobs listed with the Placement Office declined by 25 per cent.

A secondary effect of the depressed state of the economy is reported in the experience of the Admissions Office during the year. Professor Roland Greeley's report records a 20 per cent decrease in freshman applicants for the class of 1975, a reversal of the trend of the number of years of increasing applications. There is no single cause of this shift. Our soundings, however, suggest that the general state of the economy, the decline in R&D spending, and, therefore, the demand for engineers and scientists, and the rising cost of private higher education all have had a dampening effect on our freshman applications. This does not, as Professor Greeley points out, reduce the number of freshmen actually registering — actually the class of 1975 is a little larger than previous classes — but clearly, we could not sustain the continuing decline of this magnitude in applications without seriously affecting either the size of the freshman class or its quality.

Jack Frailey, Director of the Student Financial Aid Office, characterizes his program as one faced by "increased need and shrinking resources." As the increasing costs of operating the Institute are reflected in higher tuition and other charges, so is the student's financial burden greater. Our calculated need for financial assistance among undergraduates rose to nearly $5,500,000, a 12 per cent increase over the preceding year. Since our scholarship funds have not been growing as rapidly as the undergraduates' need, an increasing proportion of the need has had to be met by "self-help" — loans and/or term-time jobs. We clearly must enlarge the pool of scholarship and loan funds. In addition, under Mr. Frailey's leadership, we have been studying intensively means in the longer run to assist the student in paying for an M.I.T. education, and to find the capital to provide that assistance.

The report of the Office of Personnel Relations Director, Robert Davis, illuminates still another aspect of our general economic situation. Nonacademic employment declined by over 3 per cent with 340 jobs eliminated between January 1, 1970, and June 30, 1971. Fortunately, the office was successful in finding other positions at the Institute for nearly half of those laid off, for employment opportunities were not plentiful in the Boston area. This lack of opportunities elsewhere was undoubtedly also a major factor in sharply reducing turnover through voluntary termination during the year.

After a decade of major expansion in the Institute physical facilities through construction, the report of O. Robert Simha, M.I.T. Planning Officer, records a marked shift in our activities. While he reports on three major construction projects, the Electrical Engineering and Communications Research Facility and the Westgate II graduate housing facility, both under construction, and the Chemical Engineering Building

in the planning stages, most of the emphasis of the report is on the conversion of existing space to new uses. With growing programs related to health sciences and technology, environmental research, and urban studies, and without the resources for major new construction, the Institute must put its primary emphasis on innovation in the effective use of the existing space and in lowering the cost of physical improvements. We must find less expensive ways of accommodating new programs at M.I.T. within existing facilities.

Despite layoffs, reduction in turnover, and general fiscal constraints, the Institute has been determined to press ahead with its commitment to affirmative action in providing educational and employment opportunities for women and members of minority groups. James C. Allison, Jr., Opportunity Development Officer, has reported on our efforts to increase employment opportunities at the Institute, and other economic opportunities for the minority community through our contracting and purchasing activities.

During the year, an audit of M.I.T.'s performance as an equal opportunity employer was undertaken by the Boston Office for Civil Rights of the Department of Health, Education, and Welfare. While the audit was not completed nor a report received by the end of the year, the audit process itself was of considerable value in pointing out means for further improvement.

The Analytical Studies Group continued its work on resource management problems of higher education under a grant from the Ford Foundation. The principal emphasis during the year included an analysis of the medical services offered by the Institute, including an alternative means for delivering medical care to a larger segment of the Institute community and their families; the further development of a computerized management information system for the Institute's academic departments; and studies of a number of policies relating to the management of resources at the Institute, including financial aid resources and manpower policies. A further specific study undertaken during the year was a review of institute policies and procedures coordinated by Dean L. Jacoby. The objective of this study was to bring our existing policy and procedure documents up to date and to republish them in a format which will permit regular modification and amendment as policies and procedures change.

The reports which follow examine in more detail the problems and issues which have here been summarized and identify the approaches being taken to deal with them. Those which stem directly from a downturn in the national economy, such as placement of students and alumni, should yield to an improvement in the economy. Those which derive

directly from inflationary pressures and Institute costs will prove less tractable and will demand a maximum of imagination and energy from us. I am confident that those who direct and support the operations of these offices will be equal to that task and trust that the next report will record their progress. Finally, for his able assistance to me and others in the Institute administration, I wish to express my appreciation to James J. Culliton who came to M.I.T. as Assistant to the Vice President for Administration and Personnel in September, 1970.

JOHN M. WYNNE

OFFICE OF PERSONNEL RELATIONS

In addition to performing their regular functions and services during the year, the staff of the Office of Personnel Relations found themselves devoting considerable amounts of time to new or augmented equal employment opportunity activities, the introduction of a new training program, the procedural and personal problems entailed in the Institute's layoff affecting some 340 individuals, and union negotiations which were prolonged beyond the July contract termination date into September, 1970.

EMPLOYMENT

Continuing the downward trend begun in fiscal 1970, nonacademic employment in the year just ended declined by 3.3 per cent to 7,304. Employment on the campus fluctuated within a narrow range during the year while at the Draper and Lincoln Laboratories it decreased steadily and more rapidly than in the preceding year:

	June 30, 1970	June 30, 1971
Campus	4,142	4,109
Draper Laboratory	1,729	1,571
Lincoln Laboratory	1,684	1,624
All M.I.T.	7,555	7,304

In the most extensive reduction in force in many years, M.I.T. gave notices of the elimination of 340 jobs between January 1, 1970, and June 30, 1971. Through concerned efforts, other positions were found at M.I.T. for 154 of the persons affected. Efforts continued to find places either at M.I.T. or elsewhere for 37 other persons still on notice of layoff, as well as for some of the 154 persons terminated who had not

yet relocated. To help meet the problems associated with layoffs, policies were developed to afford greater job protection for long-service staff members and to give laid-off personnel preferential consideration in the filling of vacancies as they occur.

TERMINATIONS

Although terminations from causes other than layoff dropped significantly during the past year, this office took further steps to increase employee satisfaction and reduce the causes of voluntary terminations. These steps included several ways of soliciting opinions from present employees, those about to terminate, and those who have recently terminated.

EQUAL OPPORTUNITY PROGRAMS

Despite reduced employment needs, the Office of Personnel Relations continued during the year to innovate and experiment with methods of minority advertising and recruiting. The figures reported to the Federal government for 11 months of 1970 showed only modest headway toward our goals of increased percentages of black and Spanish-surnamed American employees. The Institute's revised Affirmative Action Program, which calls upon each department and laboratory to state its own equal opportunity goals and its plans for attaining them, should do much to further the overall program for placing and upgrading both minority group members and females.

A review of the Institute's equal employment practices and affirmative actions was begun by a resident team from the Department of Health, Education, and Welfare in the spring of 1971. This review has involved close examination of recruiting practices, referral and employment procedures, training, transfer and upgrading, salary administration, and all other aspects of employment, with special attention to the equitable treatment of females as well as blacks and other minority group members. At the close of the fiscal year, no findings or recommendations had been issued.

TRAINING PROGRAMS

The spring of 1971 saw the near completion of two phases of M.I.T.'s Technical Training Program, in which 34 young people, many of them black, had been hired and trained in the skills of electronic technician, machinist, or draftsman. Although as in most such programs there were some problems and failures, 14 employees completed the formal period of on-the-job training and basic education and remained in their same jobs while nine others are continuing their training. Five of these

are in a smaller technical program at the Lincoln Laboratory. Meanwhile, an Office Skills Training Program was launched in 1971, also partially funded by the Department of Labor. Basic education, counseling and classroom instruction are combined with on-the-job training for 23 new employees to become qualified technical typists, computer operators, accounting clerks, and graphic arts assistants. Space has been made available for a small training center including a typing room, a classroom, and offices for the training supervisor, coordinator, secretary-instructor, basic education instructor, and two counselors.

LABOR AGREEMENTS

Agreements were concluded in September, 1970, with unions representing some 2,100 employees in five bargaining units. The major agreements cover two fiscal years and provide for wage increases of 10 per cent in the first year and 8 per cent in the second year, as well as improvements in the pension plan, a new long-term total disability income plan, and other provisions.

WAGE AND SALARY ADMINISTRATION

This office continued to conduct and participate in surveys of employers' compensation scales and fringe benefits as one basis for recommending fair and competitive programs for the Institute. The salaries of over 5,000 staff, exempt, and office personnel and the wages of more than 1,000 hourly-paid personnel were reviewed by their supervisors to recognize meritorious performance by increases within the approved framework. In all reviews, and particularly those of staff and exempt personnel, special attention was given to making certain that females and minority group members were equitably classified and paid in relation to all other personnel.

FRINGE BENEFITS

In the Institute's well-rounded benefit program, the major paid benefits alone — life insurance, health insurance, total disability income, and retirement plans — can be valued at approximately 16 per cent of payroll. During the year, the cost of Blue Cross-Blue Shield hospital and medical protection, which has been rising steadily, increased 32 per cent and other benefits costs rose also. Inasmuch as M.I.T. pays from over half to all of the cost of these benefits for various categories of personnel, it absorbed the major share of the cost increase.

One benefit improvement made during the year which did not add to M.I.T.'s costs was a substantial increase in the retirement benefits for faculty and staff members, both those already retired and those who will

retire in the future. The improvement was financed from funds already in the retirement plan resulting mainly from favorable investment experience.

TUITION ASSISTANCE

Employees and members of the research and administrative staffs continued to make use of the tuition assistance plans to further their educational development in ways related to their work at M.I.T. The preponderance of study by staff members is at the graduate level at M.I.T. Employees study mainly at local evening schools, and more than half of them are in pursuit of degrees. One course chosen by a significant number of employees was the Lowell Institute School's two-year program in Computer Technology.

As a step to make tuition assistance truly available to all employees with a minimum of uncertainty and financial risk, a scheme of one-time prepayment was introduced this year. The first time an employee enrolls under the tuition assistance plan, M.I.T. prepays his tuition up to $250 and will accept a grade lower than C.

DAY CARE

The Institute again participated in the KLH day care program for children from 2½ to 6, partially funding positions for 15 children of 12 M.I.T. employees. As openings occur they are being used in conjunction with recruiting efforts to see whether a subsidized day care service can significantly increase the number of parents, especially mothers, who will take and hold regular full-time jobs at M.I.T.

UNEMPLOYMENT COMPENSATION

Following a change in Federal law, enabling legislation is pending in the state legislature which will extend the coverage of the Unemployment Compensation Act to educational institutions effective January 1, 1972. Aside from the burden of administration and reporting, the payments involved in maintaining unemployment compensation coverage will constitute a major increase in the Institute's cost of operation.

PERSONNEL INFORMATION SYSTEM

Working closely with the Office of Administrative Systems, the Office of Personnel Relations took further steps to extend the presently limited application of data processing to its personnel records. A completely computerized personnel records system will make possible a more effi-

cient procedure for career development and promotion from within as well as greatly facilitating the preparation of the varied and often voluminous reports required of this office.

ROBERT J. DAVIS

PLANNING OFFICE

The report of the Planning Office for the past year provides some clear indications that the tempo of planning activities at M.I.T. has not diminished but has rather quickened as resources for development become scarcer. I expect this trend to continue because long-range planning is essential to ensuring that the Institute's ability to initiate or respond to new opportunities is protected and that the necessary resources are available where and when they are needed. More energy will be required to ensure the effective use and improvement of existing space resources as the competition for these resources increases. The need for innovation in the effective use of space and in lowering the cost of physical improvements will continue to be high on the agenda. Planning systems that not only provide more dependable data but reduce the man hours required in any number of planning operations is essential. Opportunities to reduce costs of our operations through cooperative agreements with other institutions or research that seeks new ways of making higher education make more effective use of its facilities should be one of our major concerns.

I see, particularly with a new administration leading the Institute, the need for:

1. Our quinquennial plan review to proceed in the coming year;
2. A clear set of planning priorities to ensure the most effective use of the Institute's planning resources;
3. A continuing effort to improve our environment; and
4. Better management, construction and space use techniques that can help reduce the cost of construction on our campus.

The reports of each of the Planning Office groups that follow review the past year and set the stage for the future.

LONG-RANGE PLANNING

During the past year, the Pilot Plan project for the Northwest Area constituted a major effort to answer some of the pressing questions about the Simplex properties and related land in the surrounding area. It was a pragmatic effort aimed at establishing several things: the scope of activities which could be accommodated in the area; cost-benefit esti-

mates and financing mechanisms; effective organization and time scale for development; and available options for all important constraining factors. By the year's end many important questions were answered and new questions had been raised. The effort continues.

Other activities of the Long-Range Planning group were more varied. They included a comprehensive review of athletic facilities and needs, completion of technical reports of detailed data from faculty-staff and graduate student housing surveys, and development work on several basic data files and reports which are intended ultimately to be maintained and/or generated by computer, including detailed data on Institute investment and academic properties, M.I.T. population trends in recent years, and student residence types and locations. Community development work was performed with the Tech Nursery and with the establishment of a Teen Center in Cambridgeport. Extensive effort also culminated in establishment of a day care pilot program for children at M.I.T.

In addition to the above, the Long-Range Planning group assisted the Planning Officer in drafting a proposed PPB approach for organizing and managing the office's overall work program.

Members of the Long-Range Planning team were active in their professional societies, some holding national offices.

BUILDING PROGRAMMING AND DESIGN REVIEW

During the year, the Building Programming and Design Review group has been involved in a wide variety of projects in two major areas. In the preparation of proposals and final programs and in the design review of projects, we have worked closely with students, faculty, and administrative staff to ensure a broad range of involvement of the M.I.T. community in the planning process. The following list indicates the scope of these efforts in the two major categories.

FACILITIES PROGRAMMING

1. The preparation of a final proposal for facilities for the Department of Chemical Engineering, revised from the proposal issued last year, with updated site studies and budgetary information was undertaken with the assistance of Professor Raymond Baddour and his staff. This proposal was distributed to the administration and the Chemical Engineering Visiting Committee.
2. A program for renovation of the Department of Urban Studies and Planning was prepared with the assistance of Professor Lloyd Rodwin and his staff.

3. A program for renovation of classrooms in Building 4 was completed with the aid of Messrs. Wells and Cook of the Registrar's Office.
4. A program for the renovation of offices and classrooms in Buildings 2 and 4 for the Department of Mathematics was prepared with the assistance of Professor Kenneth Hoffman and his staff.

DESIGN REVIEW

The design review of the following list of projects was accomplished in periodically scheduled meetings, which included the architect and the members of the client team for each project. The client teams included faculty, students, Physical Plant, and other administrative personnel appropriate to the particular project. The planning staff coordinated these review sessions and issued the appropriate design review memoranda to persons involved.

1. Design review of the M.I.T. Infirmary renovation project with the client team, including Dr. Clark, Dr. Caplice, and others was completed. The facility was completed and occupied by the Medical Department in September, 1970.
2. The design for the M.I.T. Press renovations was reviewed with the client team representing the Press, including Messrs. Webber and Haas, and Miss Cooper. The spaces were completed and occupied in the fall of 1970.
3. The modified plan for the Massachusetts Avenue crossing project was completed and installed during this fiscal year and included new street tree and grass planting, two bus shelters at 77 Massachusetts Avenue, planter tubs, and new lighting and signal devices.
4. Design review of the Electrical Engineering and Communications Research Facility with members of the client team, including Professors Smullin, Pennfield, Zimmermann, Mr. Power and other members of the department, R.L.E. and Physical Plant personnel was completed. This project is now under construction and is scheduled for completion in the summer of 1973.
5. Design review of the Westgate II project for graduate housing continues. Members of the client team include a group of graduate students, as well as the architect, Messrs. H. Miller and P. F. Barrett, and others from the administration. Progress meetings are also being held with the contractor and the architect. The building is now under construction and scheduled for completion in the fall of 1972.
6. Design review for renovations to the Department of Urban Studies and Planning was carried on with Professor Lloyd Rodwin and his staff.
7. The design for renovating classrooms in Building 4 was reviewed

with Mr. Wells and Mr. Cook of the Registrar's Office. These classrooms are scheduled for renovation during the summer of 1971.

8. Design review for renovation of classrooms and offices in Buildings 2 and 4 for the Department of Mathematics was undertaken with the assistance of Professor Kenneth Hoffman and his staff. These spaces are scheduled for renovation during the fall of 1971.

9. Design review for the renovation of spaces in Building 6 for the Department of Chemistry, represented by Professor John Irvine was completed. These spaces are now under construction.

10. Continuing review of major renovations to Burton-Conner was conducted with the architect, contractor, and administrative staff. This project is scheduled for occupancy in September, 1971.

11. Design review for the Carr Tennis Facility was undertaken with Professor Ross Smith representing the Athletics Department. This project will be constructed in the summer of 1971 with occupancy scheduled for the fall of the same year.

12. Final design review for the Astrophysical-Geophysical Observatory in Westford, Massachusetts, was carried with Professor Tom McCord representing the users in this case. The building was occupied in June, 1971; the installation of telescopes will be completed in the fall.

13. Design review of landscape improvement projects included the planting of the Hosta Garden, given by Miss Constance Williams in the Building 10 courtyard and the installation of planting pots on Vassar Street.

14. An extensive program for renovation of the main corridor was undertaken, including the painting of walls and stairwells and the installation of a series of exhibitions. These exhibitions were coordinated by the Planning Office, with assistance from students and faculty of the departments involved, such as Athletics, Electrical Engineering, M.I.T. Press, Earth and Planetary Sciences, R.L.E., Metallurgy, and others.

SPACE ADMINISTRATION

Administrative services for 90 space change projects were provided during the year. Services included limited or extensive planning, determination or evaluation of requirements, preliminary cost estimating, scheduling, negotiations with competing groups, surveys, and studies.

Close surveillance of available funds was observed during the year. Greater efficiency and increased detail in investigation of and preparation for each project was required within the Space Administration group as well as by those who must make the difficult decisions for implementation with limited physical and monetary resources. Complete justification was necessary in each case.

Eighty space assignments were made, exclusive of those for newly occupied buildings. Assignments were made with the authority, approval, or direction of the Subcommittee for Space Planning. Approximately 250 rooms were reassigned. Assignments were made in most cases in compliance with requests for new space to accommodate expanding activities. New space was provided largely by upgrading space having marginal utilization or, less frequently, arranging for reassignment of space by Institute organizations with diminished activity.

Retrieval of space with low utilization for general Institute use is not often accomplished since utilization is extremely difficult to measure by other than empirical means. In addition, it is frequently the case that low utilization periods are only temporal. Space assignments are ordinarily made following negotiations and agreement of all interested parties.

Space data is machine-recorded and maintained for over 17,000 rooms of the Institute. Planning Office records include 5,373,378 square feet of academic space. In addition, personnel and specific activity of the space are recorded for selected areas where special study of space allocations may be required.

PLANNING SYSTEMS

The Planning Systems group has focused much of its effort this past year on providing both the Planning Office and the M.I.T. community at large with the ability to understand better the physical environment of the Institute and how it is used. At the detailed level of physical facilities information, the INSITE space inventory system has provided both detailed and summary reports on the 17,000 spaces at the Institute to nearly every M.I.T. department administrator as well as to several Federal and state agencies that annually seek such inventory data.

The use of INSITE this year to provide an analysis of the current painting cycle of the Institute's physical plant, with the further ability to provide a paint program based upon management's allocation of financial constraints, was the first such application at any academic institution, to our knowledge. The extension of this ability to analyze replacement programs for any physical materials with a limited life such as floor coverings and venetian blinds will continue in concert with both the planning and operational needs of M.I.T.

The ability of our space inventory system to provide management with both a planning tool and an operational control device for its physical resources has continued to draw much attention from numerous academic institutions throughout the United States as well as from other countries. Fulfillment of the many requests for information from these universities was accomplished through the publication of a lay description of INSITE's abilities in a professional society's journal and a more tech-

nically oriented user's manual. The possibilities of obtaining external funds for sharing the INSITE system with other universities appears great and will be a focus of more attention this coming year.

Another level of physical resource information soon to be available is the building data and land data files for M.I.T.'s investment properties. Also concerning buildings, were two important reports published this year on the calculations and summaries of the gross floor area of all M.I.T. academic buildings.

Systems assistance to the long-range planning effort of the Planning Office was provided in two areas. The first was the statistical analyses of three questionnaires circulated by this office: the Faculty-Staff Housing questionnaire, the Married Student Housing questionnaire, and the Burton-Conner Student Interaction Study. The second was the development of MITCAP, an M.I.T. Capital Budget model, with the assistance of a graduate student from the Sloan School of Management who made it the topic of his Master's degree thesis. Use of the MITCAP model now provides our office with a more rapid response capability to requests for analyses of alternative capital budget programs.

In addition to the above, the Planning Systems group has assisted the Planning Officer in the administration of the office and, in particular, with the analytic effort in preparing a preliminary PPB report for the office's work program.

O. ROBERT SIMHA

ADMISSIONS OFFICE

TRENDS IN UNDERGRADUATE APPLICATIONS

After many years of gradual increase in the applicant yield, the per cent of those to whom we offered admission who actually registered in 1970 took a sudden drop. Similarly, the small but consistent annual increase in numbers of completed freshman applications ended abruptly this year, and we experienced a disconcertingly large drop in applications. This was no isolated phenomenon: it was experienced by virtually every well-known technological institute or engineering school and by most of the private colleges. Probably the suddenness and magnitude of the drop reflect the coincidence of several factors, as there is no one factor which seems to dominate.

The Admissions Office inquired of many of its guidance counselor friends what they saw as the principal causes of these changes in college aspiration. Two hundred replies give a highly illuminating and in some respects disturbing picture. The generally gloomy economic picture, coupled with the current publicity about dearth of opportunities for pro-

fessional engineers were frequently-mentioned factors which were, of course, anticipated. Many respondents mentioned the increasing preference for college programs related directly to social and humanistic goals, and this certainly suggests that we at M.I.T. must stress much more than we have the deep concerns shared by most departments for improvement of our environment, both natural and urban, and for bettering social conditions through humanitarian applications of technology.

Perhaps the most significant single factor emphasized in the questionnaire answers was the marked decline in the relative drawing power of prestige institutions, in comparison with that of the fast-growing public colleges and universities. This observation took many forms, from questioning whether the cost in money and effort of the M.I.T.'s produced measurably better results than could be obtained at the University of X, to the more earthy question of why one should devote years of professional education to becoming an electrical engineer when a licensed electrician can make as much money. Then there was reference, by many, to the increasing — but still small — number who just basically question the validity (for them) of institutionalized education.

The rationale behind these observations may be attacked in many respects, but that is not the purpose of citing them here. They represent existing viewpoints of thousands of high school students. These attitudes are facts with which we must cope, and if they persist, or grow, they will have profound implications for the future of private colleges — even ones as well-known and widely respected as M.I.T. As for the long range, one can hope that the cults of mediocrity and of obvious relevance will wane. In the immediate future we must redouble our efforts to attract a balanced applicant group, lest our class become bimodally distributed between those who can easily afford M.I.T. and those whose financial resources are so limited that they depend almost entirely on outside aid for their college education.

Despite the 20 per cent decrease in freshman applicants, the Class of 1975 is a little larger than previous classes, due largely to an increase in the number of women (130 as compared to 90 last year). The normal measurements of quality, especially CEEB test scores, indicate no appreciable change over the past 3 years (average CEEB test score is down 6 points).

SELECTION OF FRESHMEN

In cooperation with the Faculty Committee on Undergraduate Admission and Student Aid we conducted a new experiment in the selection process: about one-third of the applications, including all of the U.S. female applicants, were apportioned for review and decision among 5 teams.

Each team consisted of two faculty volunteers and one Admissions staff member. These three individuals reviewed about 250 applications and made the selection decisions, subject only for overall review for consistency within the individual school systems. As a check on this experiment, a random sample of the same applications were subsequently reviewed and acted upon, in the normal manner, by the Admissions Staff acting as a group. This revealed surprisingly little difference in the results of the two processes, a significant difference in only 6 per cent of the cases, and no clearly discernible "patterns" of difference. The faculty persons involved felt the experience was so rewarding that they advocate expansion of this process next year. Few, if any, expect that such expansion will affect discernibly the composition of the class.

Review and selection of minority-group applicants was conducted again this year by a special review group, consisting of members of the special Task Force and of the Admissions staff. They found slightly fewer students to be admissible this year, with the result that the number of blacks in the class is just under 50, and the Summer Interphase program is a little smaller than last year's.

RECRUITMENT

Efforts to recruit blacks and members of other minority groups continued, with somewhat increased emphasis. The national lists, especially the list of National Achievement Scholars, continue to be the best source of applicants from the black community. The lack of similar lists for Spanish-Americans and American Indians makes it much harder to effect meaningful contacts. Support of the Boston-area Union of Mexican-American Students helped first-person contacts with many colleges and secondary schools in the Southwest but brought us very few students. Contacts with some of the groups working directly with American Indians have thus far been encouraging but not productive of meaningful applications.

Our efforts in the above special programs must continue unabated. At the same time, we must recognize that the expensive high-prestige private institutions are losing some of their general drawing power throughout much of the United States. It will be necessary, therefore, to redouble our efforts over the next few years to strengthen the overall recruiting program, especially outside of the major metropolises and in those sections of the country from which we currently get few applications.

During the year, several factors combined to accentuate the policy of welcoming more women as members of the undergraduate student body. Increased popularity of coeducational institutions, increasing num-

bers of applications to M.I.T. from women, and the popularity of some aspects of the women's liberation movement all combined with the decision on the part of some M.I.T. living groups to become coed to bring about lack of restraints on the admission of women students in principle as well as in practice. We revised some of our published statements to emphasize the fact that we are coed and have been for a century; and we stepped up our efforts to appeal to women in visits to general schools and to traditionally women's schools. The resultant nearly 50 per cent increase in number of coeds in the Class of 1975 is the biggest single numerical increase in our history, but it may be equalled next year or the year after.

TRANSFERS, FOREIGN STUDENTS, AND GRADUATE STUDENTS

The numbers of applications from foreign countries continues to hold up remarkably well. Finances seem to be increasingly critical, chiefly because governmental support, both from home and from the U.S., seems to be on the wane. The Faculty Committee has reviewed critically the policies governing admission and aid to foreign undergraduates, endorses present practices, and acknowledges that discretionary judgment must be used at times to bring about balanced geographic and socio-economic distribution of such students.

The status of transfer admissions is relatively stable. No marked increases have yet materialized, although the number of applications was up again this year. It appears likely that the pressure for us to accept more transfers will become great, especially if we make it generally known that eligibility for financial aid and housing is on a par with continuing students.

Although the numbers of graduate applications were down this year from the abnormally high 1970-71 figures, they were appreciably higher than those for previous years. Hoping for essentially the same numbers of registrants as a year ago, departments admitted just about the same number of students. Some dip in the yield, induced at least in part by reduction in the numbers who could be offered financial assistance by M.I.T., resulted in a smaller total number of new graduate students. At the same time, significant decrease in the number of Special Graduate Students brought about a markedly lower total headcount of graduate students.

OPERATIONS

Mrs. Juanita L. Stuller left in December, 1970, after 5 years of highly effective service as the first alumna member of the Admissions staff. Her able replacement is another alumna, Cynthia C. Helgerson, '70.

In November, 1970, we held a special Conference for Secondary Math

and Science teachers, a variation from the annual Guidance Counselors Conference. Attended by 75 teachers, from 28 states, the Conference proved to be an effective device for getting the M.I.T. story impressed upon some of the outstanding teachers in the country. Whether it was more effective in establishing fundamental relationships with secondary schools than the Guidance Conference is an open question.

The work of the Educational Council continues to be an essential component of the total Admissions program. Without the support of this group of devoted alumni our work would be much more difficult, and the preliminary applicants throughout the world would be deprived of counsel that is valuable both to them and to M.I.T.

ROLAND B. GREELEY

Admissions Office Statistics 1970-71

	1969	1970	1971
Entrants from secondary schools:			
Preliminary applications	7,214	7,648	6,468
Final applications	4,585	4,896	3,842
Admissions offered	1,483	1,600	1,758
Actual registrations	957	942	983
Registrations as per cent of admissions	64.3%	58.8%	56.0%
Number of secondary schools represented	729	737	804
Per cent of students from nine northeastern states	51%	45%	50%
College transfers:			
Total applications	637	773	829
Applications completed	318	381	348
Admissions offered	131	143	150
Actual registrations	109	120	100
Registrations as per cent of admissions	83%	84%	67%
Graduate students:			
Total applications	6,189	6,556	6,485
Admissions offered	2,333	1,952	2,111
Actual registrations	1,258	1,015	1,191
Registrations as per cent of admissions	54%	52%	56%
Number of personal interviews:			
At M.I.T.	1,916	1,949	1,791
By Educational Counselors in New York City	226	245	183
Other regions	2,895	2,991	2,523
Total	5,037	5,185	4,497
Number of persons taking tours of M.I.T.	4,878	4,057	3,630
Number of secondary schools visited:			
By Educational Counselors (College nights)	123	125	111
By Faculty and Administrative Staff members	81	59	57
By Admissions Office staff	170	219	413
By students	144	109	28
Total	518	512	609

Advanced Placement

	Number of students seeking credit		Number of students receiving credit		Number of subjects credited	
	1969	1970	1969	1970	1969	1970
Procedure:						
College Board test program	481	426	375	267	581	450
Advanced Standing Examinations	54	7	43	7	55	14
College transcript	54	37	51	36	93	96
"A" Level Examinations	—	16	—	16	—	35
Total	545	486	428	326	729	595

Subjects credited	Number of terms credited		
	1968	1969	1970
Chemistry	18	107	112
Physics	13	71	78
Mathematics	354	379	254
Other specified subjects	4	15	22
Elective credits (6 units each)	136	132	108

EDUCATIONAL COUNCIL

The most significant role of M.I.T. is the education of first-calibre young people. Our job continues to be enabling a group of Alumni Educational Counselors who care about M.I.T. and young people to be of service to the Institute and secondary schools in fulfilling this most important role.

The emphasis in the Educational Council during the past year has centered upon the problem of communicating an understanding of the changing nature of M.I.T. as an institution to the Council Members. This focus is essential if Educational Council members are to adequately represent M.I.T. to their local communities. It is and will continue to be the heart of the role for the Council staff in Cambridge.

In communicating with the Council Members a wide variety of mechanisms were used. We continued to place high priority upon field work by the Council staff and members of the Admissions Office staff. We have used joint Council and M.I.T. Club meetings to a limited degree, as well as a number of joint Educational Council and school counselor and/or teacher meetings. We continued our popular program of faculty lectures to high schools, thanks to Professors James D. Bruce, Charles K. Crawford, Patrick M. Hurley, Theodore P. Labuza, Frank E. Perkins, and Bernhardt J. Wuensch.

This year, through significantly increased cooperation on the part of undergraduates and Council Members, we were able to expand the points of contact of current students with Educational Council Members and applicants to M.I.T. According to a survey of M.I.T. students from the Northern California area, conducted through the efforts of the San Francisco Area Regional Chairman, Denman K. McNear '48, the major gap to be filled in our admissions process is contact with current M.I.T. students. Therefore, this emphasis is one which will continue to expand during the next several years.

Operationally, we have expanded the number of blacks and women who are Council Members. We continue to engage all Council Members in the active search for qualified blacks and other disadvantaged students, as well as serving their more traditional applicant population. Our film library has expanded to include a first-rate film on the 1970 Clean Air Car Race. We continue to provide many and varied written communications to Educational Counselors both for their own information and for dissemination to secondary schools and students.

The Council's thanks go to the staff — M. William Dix, Jr. '67, Mary J. Manning, Jackie F. Womble, and Karen J. Brown, who provide the support for all its operation.

WILLIAM J. HECHT

STUDENT FINANCIAL AID OFFICE

The Institute's financial aid program was again characterized by increased need and shrinking resources, and despite the continued overall strength of our program relative to the past and relative to many other schools, the operation of the Office during the year was clouded with concern for the future.

Tuition took its biggest jump in history, rising 16 per cent from $2,150 to $2,500. As a result, the need for financial assistance among undergraduates rose from $4,828,081 last year to $5,424,350 in 1970-71 — a 12 per cent increase. The average need of the aid recipients was $2,390, as against $2,150 last year. The growth of scholarship and loan resources during the year was insufficient to meet the need fully, as we stated it would be in last year's report. To close the gap, each aid recipient was asked to work during the school year or to seek an additional loan from sources outside the Institute. The average scholarship grant awarded was $1,420, compared with $1,230 last year for needy

recipients. The average loan was $930, down from last year's average of $1,080. (Were it not for the shortage of loan funds and the new role of term-time earnings, the average loan award would have been larger.)

SCHOLARSHIPS

Last year's unexpected rise in direct grants to students from outside agencies was not repeated. Outside scholarships dropped from $705,054 last year to $646,224 this year. It was thus necessary for us to use for scholarships the entire amount programmed for use at the start of the year from M.I.T.'s unrestricted operating income — $325,000. The investment income on the scholarship endowment yielded $1,378,475, an increase of 13 per cent over last year's figure. Also showing an increase was the total amount realized from annual gift scholarships, reflecting in part the tuition increase acknowledged by the donors involved. The $502,659 received represents a 3.5 per cent increase over last year's figure. This category of scholarships, which includes the Federal Educational Opportunity Grants Program, continues to be an unpredictable source of aid, since nearly every year established donors phase out their programs at M.I.T. even as other donors are establishing new scholarships.

Extraordinary support of the minority-group students enrolled as freshmen and sophomores entailed the allocation of $142,450 in special scholarship awards, to substitute for the usual loan-and-job portion of the award package.

The total amount, from all sources, used to provide scholarship aid to needy undergraduates was $2,995,208, an increase of 10 per cent over last year's total. In addition, 153 students received $242,200 in scholarship awards unrelated to financial need, from agencies outside the Institute.

During the year, the scholarship endowment was increased by the establishment of 3 new funds, and a significant addition to another. These represent an increment of $400,012 in the endowment. The total principal in these funds is now $19,108,514.

LOANS

For the second year, graduate students were denied access to the Institute's low-interest loan funds, which were used entirely in the undergraduate classes. Graduates were asked to borrow from commercial lenders under the Federal Guaranteed Loan Program, or to accept M.I.T. loans bearing 7 to 8 per cent interest, the capital for which was borrowed in turn by M.I.T. from area banks.

The total amount loaned by the Institute to graduate students was $518,405, an increase of 10 per cent over last year. In addition, graduate students borrowed $153,600 from commercial Guaranteed Loan Program lenders.

The undergraduate loan picture was dominated by the National Defense Loan Program. Of $1,502,785 loaned in all, $995,929 was funded from the N.D.S.L. program, thanks to the combination of a markedly increased Federal allocation for the year, and the emergence of repayments of outstanding N.D.S.L. loans as a significant annual capital resource. The Federal program, a mainstay of our current aid program, is again beset by political controversy; and it is quite uncertain whether it will continue to exist in its present form or whether it will be modified significantly in the near future.

EMPLOYMENT

Two significant developments took effect during the year. The first involved a change in policy and the second, the addition of the Federal College Work-Study Program.

The policy change resulted in student term-time earnings being included as a financial aid, whereas in recent years aid recipients could work during the academic year without having their earnings included in their aid package. With few exceptions, award packages this year included a term-time earnings expectation of $500 to $600 in addition to scholarship and loan. Modifying this posture, however, was a loan option, in lieu of the job and in addition to other loans, open to students not wishing to work or unable to acquire a job. It is important to note that, as always before, jobs remained available to non-aid recipients as well.

The addition of the College Work-Study Program provided $270,000 to augment the substantial body of jobs open to M.I.T. students. New, professionally oriented positions, both on- and off-campus were developed, generating income and providing rewarding experience to a greater number of students.

In total, approximately 2,000 students, including 400 freshmen, earned more than $1,600,000 over the 12 months of fiscal year '71, working in the Institute's dormitories, dining halls, libraries, laboratories, and offices. During the nine-month academic year, the typical job involved 8 to 12 hours of work per week and paid a student about $500.

During the year, in recognition of their considerable contribution to the operation of this Office in a time of change and expanding mission, Mr. L. A. Hough and Mr. B. F. Moultrie were named Assistant Directors

of the Financial Aid Office. Mrs. Janice Clarke, who joined our clerical staff in August, 1969, received appointment as Assistant to the Director in September, but resigned her post in May in order to accompany her husband to a new career opportunity in St. Louis.

JACK H. FRAILEY

Table I Undergraduate Scholarships and Loans — 1970, 1971

	1971			1970
	Freshman	Upperclass	Totals	Totals
Scholarships within need				
From M.I.T. endowment funds	$ 425,454	$ 959,828	$1,385,282	$1,231,660
From M.I.T. operating funds	154,643	170,357	325,000	217,674
From gift scholarships	151,050	352,479	503,529	486,990
Direct to students	216,750	429,573	646,323	705,054
Special program scholarships	78,400	63,050	141,450	88,560
Total scholarships	$1,026,297	$1,975,287	$3,001,584	$2,752,938
Number of recipients	610	1,507	2,117	2,217
Educational loans within need				
Technology Loan Fund	$ 88,226	$ 264,660	$ 352,886	$ 738,123
National Defense Student Loans	346,299	651,315	997,614	668,925
Other M.I.T. loan funds	12,950	139,335	152,285	688,095
Total loans	$ 447,475	$1,055,310	$1,502,785	$2,095,143
Number of recipients	479	1,253	1,732	1,943
Total aid within need	$1,473,772	$3,030,597	$4,504,369	$4,828,081
Number of recipients	616	1,654	2,270	2,248
Total demonstrated need	$1,595,992	$3,838,226	$5,434,218	$4,828,081
Scholarships received beyond need				
Direct to students	90,427	151,734	242,161	187,913
Number of recipients	59	97	156	116
Loans received from outside sources				
Direct to students	70,320	325,258	395,578	273,467
Number of recipients	71	293	364	259
Faculty and employee child benefits	8,750	40,502	49,252	43,200
Number of recipients	5	21	26	31
Total scholarship and loan aid	$1,639,327	$3,556,349	$5,195,676	$5,332,661
Number of recipients	678	1,919	2,597	2,516

Table II Summary of Loan Awards, Graduate and Undergraduate — 1970, 1971

	1971		1970	
From M.I.T. sources				
Technology Loan Fund	$ 352,886		$ 656,598	
Other M.I.T. loan funds	166,290		640,380	
National Defense Student Loans	1,004,914		670,225	
Ford Forgivable Loans	20,280		30,805	
Graduate loan fund	344,926		393,258	
Federally guaranteed loans	239,460		173,548	
Subtotal	$2,128,756		$2,564,814	
Number of recipients		2033		2248
From outside sources	$ 549,178		$ 430,682	
Number of recipients		477		381
Total educational loans	$2,677,934		$2,995,496	
Number of recipients		2469		2624
Special loans				
Short-term loans	$ 104,630		$ 96,091	
Installment credit plan	—		750	
Number of recipients		306		281

OFFICE OF THE ADVISOR TO FOREIGN STUDENTS

In the annual report for the preceding year it was recorded that there were 1,352 citizens of 87 countries or political entities, other than the United States, enrolled at the Institute. Three hundred fifty-nine were undergraduates and 993 were graduates. This group of foreign students represented 16.8 per cent of the total student population. Seventy-four are women students; 417 students are accompanied by a spouse. Again, the largest nationality group is from Canada, followed by China, India and Hong Kong. The countries of the Far East supply the largest segment of the population, with Europe, Latin America, North America, Near and Middle East, Africa and Oceania following in that order.

Of the 934 graduates, 611 (65.4 per cent) are studying at the Doctoral level. Nearly half are pursuing courses in the field of engineering with a heavy concentration in Electrical Engineering.

During the period covered by this report, the foreign student enrollment decreased slightly to 1,328, but in percentage the total enrollment rose to 17.0 per cent, the largest percentage in the history of the Institute.

The figures in this census of foreign students include all individuals who are citizens of countries other than the United States. This count includes not only those students holding temporary student visas (those on F-1 and J-1 visas) but those holding immigrant visa status as well. The immigrant "student" population over the last several years has averaged about 220 people. Of the total foreign student population, 18.6

per cent was here on permanent visas, although they may not all intend to remain in the U.S. permanently.

The universities and colleges in the United States are reported to have hosted (for the 1969-70 academic year) some 147,600 foreign scholars, according to the Institute of International Education in its 1970 publication "Open Doors." This is some 11.0 per cent higher than reported for the preceding year. The foreign student population numbers about 135,000 within this total figure. In contrast, some 15 years ago (1954-55) there were 34,000 foreign students and just over 630 foreign faculty. This trend, despite the curtailing of both private, government, and foundation funding of international education seems not to have turned downward to any significant degree as yet.

ADMISSION TRENDS

In September, 1971, it is anticipated that 460 new foreign students will be enrolling at the Institute. The majority of these, some 360, will be registering for graduate degrees. Undergraduates, including college transfers as well as freshmen, will number about 100. There are, at the graduate level, 21 countries with delegations of five or more new students. The five countries with the largest delegation of admitted students this year are France (35), Japan (29), England (23), Canada (25), and China/Taiwan (21).

The 1971 freshman class will include about 57 citizens of countries other than the United States or Canada. Some 375 individuals filed final applications. Offers of admission were made to 60. There will be 26 countries represented in this class. The continent of Asia will be represented by 42, Africa by five, South America by five, Europe by six, and Australia by one.

There were 220 foreign students who filed applications for admission by reason of transfer from colleges or universities either in the United States or abroad, primarily from foreign citizens enrolled in Canadian institutions. Offers of admission have been made to 38. It is anticipated that about 30 will enroll in September. Some 20 countries are represented. There are 11 from Hong Kong, two from India, five from Pakistan, and six from Latin America. It is apparent that a disproportionate number of foreign college transfer applicants designate electrical engineering as their first choice of field of study. In some cases they are enrolled in other United States institutions not offering this as an undergraduate program. In other institutions, this field is available to them for a Bachelor of Science degree. However, the faculty and facilities in this field at M.I.T. make it a particularly attractive undergraduate program as presumed preparation for more advanced graduate work. This trend

among foreign college transfer applicants seems to be steadily increasing. This fact then, when considered with the geographic identification of the applicants, tends to further complicate the selection process in relation to the students already enrolled in that field of study at M.I.T.

The Faculty Committee on Undergraduate Admission and Financial Aid has devoted a good deal of time critically revewing the policies and practices followed in admission and in the allocation of M.I.T.'s financial resources as it relates to the needs of foreign students. It has supported the current policies, acknowledging that judgments seeking to establish a balanced geographic and socio-economic distribution must be taken into consideration. The critical problem of financial aid by M.I.T. to foreign students, is shared not only by the undergraduate but by the graduate candidates for admission as well, and increasingly by those students continuing their studies here. A proposal has been made to review this situation jointly by this Committee and by the Committee on Graduate School Policy this fall.

OFFICE ACTIVITIES AND SERVICES

The advisor and his associates, while functioning in concert with the staff of the Admissions Office on their variety of assigned tasks, also provides counseling services for all of the foreign students, and not infrequently family members, during their stay in the M.I.T. community. There is a wide spectrum of human concerns, reflected by graduates and undergraduates alike, which comes to the attention of the staff each day. We share with the faculty, and with the staffs of other offices concerned with student affairs, the desire to further the individual growth and the sense of independence and academic achievement for all those we see. These situations are often similar to those experienced by any student, but for one temporarily in a culture alien to his own, they have some fundamentally different dimensions. For example, the regulations imposed by a home government on a national abroad and the immigration laws and regulations of the United States Government are unique problems of the person who is in this country temporarily as a "foreign student." To maintain the appropriate visa status, official documentation is required. These forms are completed signed by the students, and if in order, are approved by the advisor or his deputees for presentation to the local immigration office. Assuming their passports are in order, foreign students are granted permission to enter this country for a period of 12 months. Extensions of this privilege are required annually. Documentation and official approval are also required for those seeking off-campus employment during the academic year and for those engaging in a period of "practical training" after

graduation. Extensions are perhaps matters of routine. The other situations are often more complex.

It has been the custom of the staff to provide, upon request, the required United States government forms for the individual foreign students. This was often accompanied by knowledgeable assistance and comment on their preparation. The forms were then sent to the local immigration office. Valuable time was spent to comply with these duties. Routine requests to the immigration office were generally approved, but in some cases a certain amount of indecision about the continuation of a visa status was apparent. The resolution of the attending problem was then more difficult for the student, for his faculty counselor, for his would-be employer and for his Foreign Student Advisor.

Therefore, on behalf of the foreign student community, and with the complete cooperation of the Boston Office of the Immigration and Naturalization Service the staff has instituted administrative procedures not only in the preparation of the forms involved, but in direct periodic presentation of all the completed documents to the immigration office for appropriate adjudication. Most routine requests are now returned quite promptly to the Foreign Student Office for transmittal to the individual student. Perhaps in unusual cases, or those involving the adjustment of status to that of a permanent resident, personal representation by the student is required. However, visitations by students to the Boston Office of the Immigration Service are now kept to a minimum and misunderstandings are thus avoided. This specialized counseling service is under the direction of Dr. Robert A. Schuiteman.

FOREIGN STUDENT ACTIVITIES

There are some 27 nationality clubs organized within the Foreign Student community. Among these, the Chinese Students Association, Club Latino, the Greek Students' Association, and Sangam Club (the Indian Students' Association) are among the most active in contributing a variety of rich cultural programs to the entire M.I.T. community. This list is not exhaustive and limited space prohibits comment upon all who have in many ways brought wider appreciation of the many nations represented at M.I.T. Of special note: The M.I.T. Pakistan Student Association, assisted by similar groups on other campuses, raised over $5,000 which was turned over to CARE for the support of relief activities in storm devastated East Pakistan.

The International Students' Council, through its Executive Committee helps to coordinate the activities of these nationality clubs, and sometimes provides funds for their cultural programs. Through the Executive Committee, an International Student Lounge, located on the second

floor of Walker Memorial Hall, was opened in the fall of 1970. Modest funds in support of this facility, including a grant and a long-term loan, have been awarded to the Committee by the Activities Development Board. The Council also helped organize and sponsor the first foreign student newspaper on the M.I.T. campus. Because of the outstanding leadership shown by all members of the Executive Committee of the Council, they were awarded a Karl Taylor Compton Prize for their "outstanding contribution in promoting high standard of achievement and good citizenship within the M.I.T. community." The award was accepted by Mr. Raymond Kwong, Class of '71, President of the Council.

THE M.I.T. HOST FAMILY PROGRAM

This program, organized in 1961 and managed largely by volunteers in the community, has introduced over 1,600 foreign students to some 450 participating families in greater Boston. Mrs. Robert E. Stickney is the present chairwoman of the program. She is assisted by Mrs. Robert S. Berg, the secretary, and by nine chairwomen representing outlying suburban areas. Under Mrs. Stickney's direction, a briefing session for families new to the program was held in May. About 150 people attended and received the names of new students to whom they had been assigned. Although requiring detailed planning and personal commitment, the Program offers substantial rewards through lasting friendships between those host families and foreign students who participate.

ENGLISH CLASSES FOR FOREIGN WIVES

This program, an activity of the M.I.T. Matrons Association, is now in its fifth year. Under the direction of Mrs. Stephen Crandall, it provides a conversational English program for the wives of M.I.T. students, faculty, and staff members. Instruction was provided by a faculty of 15 women to 70 women in the fall and to 65 in the spring. Participants in this program, both faculty and students, consider it to be a very rewarding experience.

OTHER ACTIVITIES

During the Summer Session, the Boston Area Seminar for International Students (BASIS), founded in 1963 as a joint interuniversity venture to assist newly admitted foreign students with instruction in English as a second language, is being hosted by M.I.T. for the third consecutive year. While the majority of participating students are associated with universities and colleges situated in Greater Boston, some will attend institutions scattered across the United States. As many as 35 of these foreign stu-

dents, largely graduates, are to enroll in various programs at M.I.T. this fall.

Another activity called PRO-BASIS, founded by a small grant from the Department of State through the National Association for Foreign Student Affairs, promotes the exchange of ideas about contemporary issues between interested foreign students and professionals in the fields of business and banking, architecture and planning.

These two programs are under the direction of Professor Robert Saitz of Boston University and Mr. Richard McDowell, formerly an assistant dean of M.I.T. An Advisory Council, comprised of administrators of international programs in other Boston and New England based institutions, serves as a policy-setting board for the programs. Mr. Eugene R. Chamberlain is the current Chairman Pro-tempore.

PERSONNEL

During the year, Mr. Tekle A. Tomlinson was appointed Assistant to the Director of Admissions and Assistant Adviser to Foreign Students. His responsibilities include supervision of foreign freshman applications and related correspondence. He also assists in the general counseling of all foreign students.

Dr. Robert A. Schuiteman, supervising the foreign college transfer applications, also continues his professional activities on various committees of the National Association for Foreign Student Affairs.

Mrs. Roy Schwitters, secretary to the Foreign Student Advisor, resigned because of her husband's transfer to Stanford University. Her cheerful assistance to students who daily visited the office will be warmly remembered. Her able replacement is Miss Cathie Brettschneider.

The Foreign Student Advisor is grateful for the continued assistance given by Mrs. Kenneth Flewelling, secretary to Dr. Schuiteman, and Mrs. Richard Lacroix, who so ably managed the voluminous mail received by the office.

EUGENE R. CHAMBERLAIN

OFFICE OF OPPORTUNITY DEVELOPMENT

In carrying out the function of coordinating non-academic minority affairs and providing suggestions for the implementation of the Affirmative Action Program, 1970 became the first year that programs initiated in 1968 and 1969 had been in operation long enough to adequately assess their progress.

It was also a year when there was a marked increase in requests and responses to minority community needs beyond the normal programs of technical and educational instance.

The increased pressure exerted by state and Federal regulatory agencies and community groups to insure equal opportunity policies and practices on university campuses resulted in a continuous dialogue with departmental representatives through meetings and memos.

The overall Institute progress has been satisfactory but has not reached the plateau projected for this year in the areas of employment of minorities and purchasing from minority suppliers, yet the accomplishments recorded, especially in community relations, has helped to offset the negative impact that all universities generate upon their neighborhood communities.

The following areas of involvement illustrate some of the primary programs carried out over the past 12 months.

COMMUNITY SERVICE

Interaction with community agencies and groups is an ongoing event at M.I.T., and in the fall the Committee on Minority Community Affairs, a subgroup of the Task Force, was formed to provide insight into planned projects in and for the minority community, and to keep an up-to-date record of the total amount of interaction that transpires between the Campus and the Community. The O.D.O. requested that departments contemplating community involvement send their programs through the Opportunity Development Office for evaluation and specific recommendations. This informal system allowed M.I.T. to support the community in a meaningful manner while maintaining its Affirmative Action aims and overall goals.

Several activities were highlighted to illustrate the use of campus facilities, such as Kresge Auditorium and the Student Center. The spring months saw conferences conducted by the NAACP, A. Philip Randolph, and the B.S.U. (in joint effort with the Community Affairs Department of the N. E. Conservatory of Music) held at Kresge.

The Boston Indian Affairs Council began using space at the Student Center for its weekly meetings and Cambridge-based groups, under a share-the-facilities plan by the Athletic Department, made extensive use of our recreation field. Mr. Smith also made the tennis courts and equipment available to the Sportsman Tennis Club of Roxbury, who sponsored a fund raising tournament at M.I.T. that attracted tennis enthusiasts from all over New England to our campus.

Future projects include arrangements for various southern colleges, that are involved in M.I.T.'s modified exchange program, to take part in

non-league sports events as well as bringing theater and glee clubs from these colleges to our campus. Plans are now under consideration to host the American Tennis Association's National Junior Matches in August, 1972, which will bring over 200 minority teenagers to our campus for a week-long event.

The Institute's position on cooperating in the development of minority business by purchasing some of its supplies from local community businesses, whenever possible, has begun to show results. Our largest impact, however, has been in the area of equal opportunities in new and renovative campus-construction. A detailed report on specific construction accomplishments can be received through this Office. The Opportunity Development Office and Physical Plant have concentrated their energies in supporting the inclusion of and sub-contractors in the contracted work with a minor emphasis on assuring the hiring of individual minorities by non-white contractors. The result has been nearly $350,000 worth of contracts awarded to 12 local minority construction companies during the 12 month period, an 18 per cent average of the various major new construction jobs. The up-coming Cambridge community housing program by Northgate Realty will hopefully involve these contractors on a long-term venture.

The O.D.O. is looking for suggestions to help M.I.T. achieve its goals in community relations. Any proposed plan of action should be brought to the O.D.O. or to Walter Milne, Assistant to the Chairman of the Corporation.

NON-ACADEMIC EMPLOYMENT

The analyzation of progress in recruiting, hiring, and upgrading minorities shows an increase in recruitment, however because of high minority turnover, a very small overall gain in total statistics resulted. Discussions within the EEO Task Force and HEW have centered on this and other specific problems and possible solutions. A final report is due in November, 1971.

Establishing programs and methods of retaining and upgrading minorities and females, took up the major part of the office's functions during the later 6 months of the year. Initial suggestions in this direction from this office to the EEO Committee have included:

1. A more comprehensive Institute-wide training program.
2. Consolidation of minority affairs by assignment of specific roles and responsibilities of persons involved in employment policies.
3. A realistic approach of more emphasis and energy directed toward hiring the qualified and qualifiable minorities rather than special programs for so-called "hard-core disadvantaged."

The latter suggestion was not to promote one plan at the expense of another, but to look realistically at which plan of action is best for a solid foundation of progress, based on budget considerations, attitudes, difficulty of jobs, and reasonable assurance of success. This change, combined with the plan to redirect responsibility of departments to develop and maintain their own Affirmative Action Plans, should facilitate implemenation through the elimination of previously generalized Institute-wide approaches to equal employment goals.

The Opportunity Development Office is in constant need of identification of the many projects being carried out in the communities by individuals and groups representing M.I.T. We are also eager to listen to any plan, program, or possible solution to a problem that will make equal opportunities for females and minorities a success.

JAMES C. ALLISON, JR.

PLACEMENT OFFICE

"Challenging" is the best one can say for the work of the Placement Office during the past year. The depressed state of the economy sharply curtailed the number of jobs available to graduating students and to alumni seeking new positions, and the Office was hard pressed to provide effective help.

STUDENT PLACEMENT

The number of firms and government agencies who came recruiting was down by a quarter, from 286 in 1969-70 to 216. The drop followed on a significant reduction in recruiting in 1969-70. Many of the firms that came had few jobs to offer. A large petroleum company, for example, which normally hires 500 technical staff members at the bachelor's and master's degree levels, was looking for only 80; instead of over 100 Ph.D.'s, it needed only 4. A noted industrial laboratory which normally attracts large numbers of candidates came only to talk with selected students it already knew. Many companies not coming explained that they would be hiring no one. While the reduction in hiring in 1969-70 had been largely confined to industries dependent on government contracts, this year hiring was down in virtually all sectors of the economy. Chemicals, oil, pharmaceuticals, machinery, metals, construction, finance, and consulting were no more interested in hiring than electronics, computers, or aerospace. Management information systems, insurance, and electric power were about the only fields in which there was significant

demand. The first is a popular field with M.I.T. students but the latter two have appealed to relatively few students in the recent past.

The situation worsened during the year. We took it as a good sign when only 3 of the 129 students graduating with doctorates in September, 1970, and only 2 of the 124 new Ph.D.'s and Sc.D.'s in February, 1971, were reported unemployed. But the statistics for June disabused us of any optimism. As of July, 17 of the 147 students graduating with doctorates in June are without a job. A disproportionate number, in comparison with previous years, have taken temporary appointments as research associates or postdoctoral fellows. A larger percentage than usual of the foreign Ph.D.'s have chosen to return home. In chemistry, to take perhaps the worst case, 13 of the 21 June Ph.D.'s have taken temporary postdoctoral appointments (at a salary, typically, of $8,000); only one has found a regular faculty position (for example, as an assistant professor); none has found a job in industry. The situation is tragic. Students who have given some of their best years to the development of skills they and their professors thought were important ask whether the effort was pointless. Often they have depended on their wives to help support them and to bear with them while they closeted themselves in the laboratory. In many cases they have had children, have skimped by living in shabby quarters, and have run up debts. No wonder some are bitter. Society, which has invested heavily in their education, is also a loser.

Rightly or wrongly, one response of students at the bachelor's and doctor's degree levels to the poor job market seems to have been to stay out of it. Far fewer students at these degree levels had interviews with company recruiters in 1970-71 than the year before. The number of bachelor's degree candidates having interviews was down from 500 to 294; the number at the doctor's degree level was down from 301 to 252. The same thing is reported to have happened on other campuses. While no firm figures are available, it also seems that larger numbers of students than normal withdrew their names from the degree list in June. Only master's and engineer degree candidates came for interviews in the same numbers as in the past.

The decline in the number of students having interviews occurred in spite of vigorous efforts to remind students of the Placement Office's existence. We contracted with Placement Publications, Inc., of Rahway, New Jersey, for the printing of a placement manual, free of charge, listing in detail the companies coming to recruit. We distributed it, along with other placement material, in September and February at registration in the Armory. During the winter Mr. Weatherall visited several of the student houses, as he did the previous year, to discuss the employment

situation and to advertise the help the Office could provide. We again invited students to include their names in a directory of graduates looking for employment. It was characteristic of this year that fewer students responded than the year before. During the Independent Activities Period the director participated in a well-attended panel discussion in the Mathematics Department on the employment outlook for mathematics Ph.D.'s. He also gave a talk in a successful lecture series on careers in the Department of Electrical Engineering. He was repeatedly interviewed by the national and local press, including *The Tech* and *Tech Talk,* and a taped interview was broadcast by WBZ.

There is evidence that students over-reacted in withholding themselves from the job market. Two blue-chip electrical firms, who were seriously in the market for new graduates, albeit in reduced numbers, lamented over their light schedules. A number of companies came whom we had not seen before. Prompted by the graduate students in the Sloan School, we wrote to all the companies on the recruiting schedule of the Harvard Business School, and not on our own, suggesting that they visit M.I.T. while in Boston. Many replied that in light of the economic situation they could not justify a visit, and indeed were cancelling dates on other campuses, but a number accepted our invitation. We hope they will continue to visit us.

We repeatedly found ourselves having to tell students that they should not be shy of the job market, that they had had an excellent education, and that if they formed a clear and reasonable idea of what they wanted, and went after it, employers would be interested in them. Many students, by searching intelligently and diligently, found first-class jobs. Others were quite unready for the task of job-hunting. Some, including a number of Ph.D.'s, started looking only after they had completed the work for their degrees. We still need to do more to prepare students for their entry into the job market.

ALUMNI PLACEMENT

The market for alumni in 1970-71 was as dismal as the market for new graduates. The number of alumni registering with the Placement Office jumped by a third, from 728 in 1969-70 to 972. Ninety percent or more were either out of work or soon expected to be. Meanwhile, the number of jobs reported to us dropped by a quarter, from 5671 in 1969-70 to 4199. We continued to hear from an encouraging number of companies (we received 1,572 different company requests) but the market was such that with our best efforts placements totalled 74. The following figures for the past twenty years, reflecting ups and downs in the market

for experienced men since the Korean War, show no other year to have been so bleak:

Alumni Placement Since the Korean War

	Number of jobs listed	Number of alumni registering	Number of alumni placed
Academic years			
1951-52	3,115	805	170
1952-53	2,934	731	150
1953-54	4,055	770	168
1954-55	3,624	912	159
1955-56	4,763	722	163
1956-57	4,967	761	171
1957-58	4,382	1,097	172
1958-59	6,977	893	154
1959-60	7,699	904	154
1960-61	5,943	961	119
1961-62	8,996	734	152
1962-63	11,417	680	144
1963-64	8,358	603	112
1964-65	10,261	576	127
1965-66	15,788	491	128
1966-67	11,842	480	86
1967-68	8,825	608	105
1968-69	7,052	575	110
1969-70	5,671	728	99
1970-71	4,199	972	74

Many of the alumni out of work have been men in their forties or fifties who had thought they were settled in their careers. They have acquired specific skills, as well as an attachment, frequently, to the communities in which they live. It is hard enough at the best of times to match a man with a job, but in their case, in the present market, it has been extremely difficult. Compounding the difficulty has been a mismatch between the men and the jobs on our books. Many of the men let go by companies have been in research or other staff positions; many of the jobs companies have listed have been line positions. In other years we would have had good candidates for these positions, but men whose skills were in demand preferred this year to stay where they were. The most we have been able to do for many alumni is to discuss their situation with them in the light of our experience of the market and to help them map out the best directions in which they might proceed. Some Ph.D.'s who have spent a dozen years or more in productive research will, almost certainly, be unable to resume their research careers. Take the example of a solid-state physicist with a string of papers to his credit who has taken a job in a high school. The longer he teaches, the less likely it is that he will ever get back to solid-state physics. He is not choosing too

strong a word when he says that his research career has probably been destroyed.

At the suggestion of Mr. James N. Phinney, executive secretary of the New York Alumni Center, and of Mr. Edwin H. Baker, president of the Alumni Club of northern New Jersey, we arranged in the fall for a member of the Office to spend two days a week at the Center interviewing alumni who wished to see us. The arrangement was announced in the Center's newsletter, which goes to 7,000 alumni in the New York City area. To our surprise, only 75 alumni availed themselves of the service. Two-thirds were already on our list of available men or had been in touch with us previously. Later, we did what we could through the mail to help members of the Alumni Club of Southern California establish a local placement service for out-of-work alumni in the Los Angeles area. In May, following the termination of the SST project, Mrs. Yates flew to Seattle for three days of interviews with alumni who were likely to lose their jobs at Boeing. She was warmly received by the company, where many M.I.T. men have made their mark.

In April we sponsored with the Alumni Association a two-day seminar on the career prospects in different fields. About 90 alumni attended, many of them dubious about their prospects in their present jobs. The discussions were informative rather than encouraging. Few speakers had a hopeful story to tell. For example, a speaker on prospects in electronics chose as his theme: "Challenge or Disaster?" Our thanks are due to a host of thoughtful panelists from the Institute and from industry who contributed to an interesting two days, among them Professor Paul A. Samuelson who catalogued in spectacular fashion the things that are wrong with the economy.

Concerned with the unemployment among alumni, the Alumni Association appointed a committee in early spring to review the needs and wishes of alumni in the area of placement and career counselling. The committee's members were Mr. Russell L. Haden '40 (chairman), Dr. Julian J. Bussgang '51, Mr. Thomas H. Farquhar '59, Mr. Gaynor H. Langsdorf '32, Mr. F. Richard Meyer '42, Mr. Donald R. Miller '50, and Mr. Martin M. Schrage '63. The committee, which invited the Placement Office staff and members of the Alumni Association staff to join it in its deliberations, recommended that the scope and scale of the alumni placement service be enlarged and that the cost be borne in part by fees charged to alumni using the service and to companies hiring alumni on referral. The charging of fees raises questions which we are still exploring, but the Institute has authorized the Office to hire an additional staff member to join Mrs. Yates and Miss Gallery in the alumni placement area in 1971-72, Mrs. Yates' last year before retirement.

To help introduce alumni and employers to each other, we started publishing in May a *Bulletin of Available M.I.T. Graduates* containing brief descriptions of alumni on our available list, identified by code numbers to preserve confidentiality. The *Bulletin* is sent to all the firms which have recently listed openings for experienced personnel, and also to all the firms that have recently come recruiting new graduates. The number of entries in each issue is limited to 50 so that it can be read through easily. The first four issues, containing entries from 196 alumni, elicited requests for 280 resumes from over 80 companies. We are waiting to see how effective the *Bulletin* will be in making placements.

MANPOWER STUDIES

One of the recommendations of Dean Sanborn C. Brown's working group on graduate and postdoctoral education at M.I.T. which reported to the Hoffman Commission was that a committee should be established to review on a continuing basis the changing market for scientific and engineering personnel. A group of faculty and staff formed itself during the year under the auspices of the Office of the Dean of the Graduate School to implement this recommendation in its own way. The group has included Deans Brown, Irwin W. Sizer, and Robert A. Alberty, Dr. Herbert Holloman, Professors Paul MacAvoy, Paul Penfield, Harvey Sapolsky, and Louis D. Smullin, and Messrs. George M. Dummer, Alan E. Harger, Eben Walker, and Weatherall. Following on Dr. Allan M. Cartter's analysis of the academic market for Ph.D.'s, we have endeavored to test industry's capacity to absorb Ph.D.'s. We have found that the starting salary of engineering Ph.D.'s in industry moves up and down quite flexibly in response to the market, with the price for new Ph.D.'s tending to clear the supply. The following equation fits the data for the period 1953 to 1968:

$$P = 0.089\ I - 0.044\ E + 596$$

$$(R^2 = 0.9851)$$

P is the monthly starting pay of engineering Ph.D.'s in industry, I is the national investment in the same year in basic and applied research, counted in millions of dollars, and E is the number of new engineering Ph.D.'s graduated that year. It appears that an additional billion dollars invested in research, with the supply of Ph.D.'s holding constant, would lift monthly starting salaries $89; the graduation of an additional 1,000 engineering Ph.D.'s, with research dollars holding constant, would depress starting salaries by $44.

The tendency of the market to be self-clearing, at least in the case of engineering Ph.D.'s, is reassuring in the present situation. We are looking for funds to carry our studies further, for example into the area of students' responsiveness to changing starting rates. Economists have given a good deal of attention in recent years to the market for scientific personnel and to the investment made by society and by individuals in scientific training, but their work has attracted little notice in the offices of graduate deans, placement directors, and directors of personnel. We should be better economists.

ROBERT K. WEATHERALL

VICE PRESIDENT FOR RESEARCH

Appearing in this section will be the report of the Director on the operations of Lincoln Laboratory during the past year and the report of the Chairman and President on the activities of the Charles Stark Draper Laboratory. Although the Draper Laboratory, an independent Division since June 1, 1970, reports to the Executive Committee through its own Board of Directors, it is included here for consistency with prior years.

The report of the Administrative Director of the Division of Sponsored Research will this year be included in the report of the Vice President for Business and Fiscal Affairs, who has line responsibility for its operation. The Division continues to report to this office on matters of research policy.

Research volume on the campus, despite the somewhat gloomy outlook which existed a year ago, increased to approximately $62 million from $58 million for fiscal year 1970. However $2 million of the $4 million increase reflects hardware procurements by subcontract, and in effect there is a small "real" decline in research volume due to inflation. Currently we estimate that campus volume for fiscal year 1972 will increase to about $69 million, including approximately $4.2 million in subcontracts, which, if realized, will be the largest increase since fiscal year 1968 and should produce some real growth. These increases are largely attributable to increases in programs sponsored by NSF and NASA and a less-than-expected reduction in Department of Defense sponsored programs.

We expressed considerable concern last year over the impact of the Mansfield Amendment on basic research supported by Department of Defense. Overall the impact was less than feared, and we were heartened

that the comparable section in the 1971 Military Procurement and Research Authorization Act effectively gave authority to the Secretary of Defense to support research which in his judgment had potential relevance to a military mission. This is considerably more flexible than Section 203 of the 1970 Act, which gave rise to such widespread concern.

There were, however, some significant but selective dislocations which occurred among campus research activities. Because of drastic cutbacks in the Atomic Energy Commission's budget for next year, the Laboratory for Nuclear Science was forced to effect a reduction in personnel and faces serious uncertainties in terms of supporting its ongoing programs and completing construction of its medium-energy linear accelerator facility in Middleton, Massachusetts.

The Francis Bitter National Magnet Laboratory, whose continued existence as an Air Force supported laboratory was in considerable doubt a year ago, ostensibly due to the "Mansfield Amendment," will receive, as of July 1, 1971, its basic support from the National Science Foundation. While the level of support for the first year will be at what amounts to a subsistence level, the future does appear brighter.

For a different reason the Center for Materials Science and Engineering, along with 11 similar organizations at other universities which comprise the ARPA Interdisciplinary Laboratory Program, is in the process of transferring to NSF. This transfer is in keeping with ARPA's operating philosophy to serve as catalyst in the process of stimulating technological innovation and to transfer responsibility for continuing operation when the start-up phase is completed. No major problems have surfaced, and the transition is proceeding smoothly.

At the Lincoln Laboratory the volume of research expenditures decreased from approximately $64 million in fiscal year 1970 to $59 million in fiscal year 1971, imposing a heavy responsibility on the Laboratory management to maintain organizational stability. The outlook for the coming year, however, is much more encouraging with a current estimate of a $70 million volume.

It is also heartening to note that the Laboratory's determined efforts to work on projects supplementary to its advanced military technology program are beginning to show results. For example, the number of personnel working on air traffic control increased from 10 to 28 over the year; a relatively new program in educational technology expanded significantly; and the Laboratory's ambulatory health care program, supported by HEW, was renewed at a rate which doubles the previous size of the program. Overall these programs remain a relatively small fraction of the Laboratory's total effort, but the trend is encouraging.

For a number of years it has been alleged in these reports, quite

correctly I believe, that it is inappropriate for the Lincoln Laboratory to be classified as a Federal contract research center. One of the unfortunate aspects of such a designation is the imposition by Congress of an expenditure ceiling which has artificially limited the ability of the Laboratory to take on new programs during any given fiscal year. While Lincoln is still so categorized, the ceiling problem is beginning to receive some attention and progress is being made toward its solution. This coming year, for the first time since a ceiling was imposed on the Laboratory, the Air Force has authorized an expenditure level of $84 million, well above the anticipated operating budget. This gap will permit the Laboratory to take on appropriate new work which might arise during the year without the need to seek relief from the ceiling. Also the Army, Air Force, and ARPA representatives who comprise the Laboratory's Joint Advisory Committee have unanimously recommended to the Secretary of Defense that the Lincoln Laboratory be exempted from the ceiling requirement.

As Dr. Gerald P. Dinneen sets forth in the report which follows, the Laboratory instituted a number of effective programs to acquaint students, both graduate and undergraduate, with research opportunities open to them at Lincoln. Last year the undergraduate participation included nine research projects, as well as seminars and specially arranged tours. Undergraduate research opportunities will be expanded during the coming year.

The major effort in research policy matters this past year, which will continue into the next, has been to create a new posture toward the inventions, innovations, and special expertise developed by members of the Institute community.

The Director of DSR has reduced the staff of the in-house patent office to a fraction of its former size and emphasized the use of reputable outside patent counsel. This step is taken with the expectation that M.I.T. inventors will perceive a prompt and more effective response in their behalf in the prosecution of patents. Effective July 1, 1971, the function of patent licensing will be combined with that of patent prosecution to provide for a more aggressive effort to license M.I.T. patents. A brochure is being prepared which describes, in brief, the characteristics of all M.I.T. inventions, which will be given wide circulation in the fall.

We are also examining the feasibility of opening new avenues for the transfer of technological developments to commercial use, ranging from providing more attractive incentives to industry to support the development of ideas to assisting and abetting the spin off of new enterprise in a variety of ways. It is our hope to develop greater flexibility in negotiating arrangements suited to the interests and objectives

of individual inventors and to create a new source of revenue for M.I.T., but in a manner consonant with the Institute's public service obligations.

Finally, this past year has seen an intensification of efforts to marshall effectively the resources of the Institute to contribute to the solution of problems related to the environment, transportation, power generation and transmission, and the delivery of health care. This task, difficult because the dimensions of the problems are so broad, is exacerbated by the continuing fractionalization of responsibility within the agencies of the Federal government and between Federal, state, and local jurisdictions. No real progress will be made until adequate funds are made available, responsibility and authority are centralized, and administrators are found who will commit funds sufficient to show results to proven centers of excellence.

ALBERT GORDON HILL
JOSEPH F. O'CONNOR

CHARLES STARK DRAPER LABORATORY

On June 1, 1971, the Charles Stark Draper Laboratory completed one year of operation as a separate division of M.I.T., the first step toward divestment of the Laboratory from the Institute in accordance with the decision announced by President Howard W. Johnson on May 20, 1970.

Policy direction for the Laboratory resides with its Board of Directors, which is elected by and responsible to the Executive Committee of the M.I.T. Corporation. We are gratified that each of the 12 original Directors, whose names appear in last year's report, continues to serve the Laboratory. Professor Albert G. Hill, Chairman, Dr. Charles S. Draper, President, and Mr. Paul V. Cusick, Treasurer, continue as the principal officers of the Division.

The Board, with its distinguished membership, has demonstrated its genuine interest in assuring that the Laboratory continues its important service to society and the nation by meeting monthly since May 1970. In addition to directing the Division, it has worked intensively on the problems of divestment.

Early in its existence the Board specified three objectives that a successful divestment must achieve:

1. A viable future mode of existence for the Laboratory, which essen-

tially means one that is acceptable to Laboratory personnel and to the sponsors of its research;
2. Consideration to M.I.T. sufficient to avoid a potentially critical financial impact;
3. Reasonably rapid accomplishment.

After gaining insight into the nature of the Laboratory, the Board reaffirmed the organizational philosophy and objectives which have characterized its successful operation since its inception in the early 1930's by faculty members in the Department of Aeronautical Engineering. Briefly stated, these are:
1. To provide a creative technological environment permitting academic and post-academic education through voluntary association with a laboratory responsible for results on real-world projects;
2. To generate significant results and to transmit them by means of unclassified publications;
3. To transfer important pioneering developments of technology by the Laboratory into effective use for the benefit of science, industry, and the government;
4. To require sufficient support from sponsors for benefits delivered to reimburse direct Laboratory expenses and a proportionate share of M.I.T.'s indirect expenses incurred in providing the institutional and human resources essential to the Laboratory's successful accomplishments.

The Board studied at length and in depth a variety of possible organizational forms which the Laboratory might assume after divestment, and late this spring concluded that a new non-profit corporation would be most likely to achieve the objectives set forth earlier.

There are a number of reasons for this conclusion, chief of which is that assets of the Laboratory are intangible. Its physical plant, equipment, patents, and copyrights are insignificant as a basis for determining its value. The vitality of the Laboratory in the future will, as it has from the beginning, depend upon creative people and their ideas, and it is clearly evident that non-profit status offers the best chance to preserve an environment of intellectual freedom and independence.

The importance of maintaining a continuing educational role for the Laboratory cannot be minimized, both in terms of the unique contribution it can offer and for the intellectual regeneration it realizes through its work with students. Non-profit status would again seem most likely to enhance future educational activities.

Sponsors of Laboratory research have testified to the high value they place on the Laboratory in addition to its technical accomplishments, as a source of objective advice on such matters as production

procurement and the effect of design changes motivated by cost reduction on the integrity of Laboratory-developed components and systems. Clearly the Laboratory can best continue to play this role without a profit motive.

Details of organization and arrangements attendant to the operation of the Laboratory are necessarily uncertain at this time, but some important agreements in principle have been achieved. The Institute and the Laboratory have agreed to the mutual desirability of continuing and perhaps enhancing educational and research interactions after divestment. Understandings have been reached about the maintenance of employee benefits, use of Institute facilities and services that would minimize the impact of separation on members of the Laboratory. Preliminary discussions with sponsors have been, in general, favorable to the plan developed, but there are still many facets of it that will require careful consideration and delicate negotiation. The task ahead is difficult, but the reward to all parties involved will be great if a reasonable and equitable divestment can be achieved.

In early June announcement was made of a key appointment to the Laboratory staff. Brigadier General Robert A. Duffy, soon to retire from the Air Force as Vice Commander of the Space and Missile Systems Organization, will become Vice President. General Duffy will bring to his new position a proven record of competence as a manager of large research programs. He is very familiar with the Laboratory and is well known to and highly respected by members of the technical staff.

Before turning to a review of Laboratory operations for the year, we wish again to pay tribute to the remarkable spirit and loyalty displayed by all members of the Laboratory. Though the stormy criticisms of Laboratory programs which characterized last year have abated, there remained the difficult task of concentrating on the jobs at hand when the future of the Laboratory seemed, at best, uncertain. The results of the year's effort bear witness as to how well they managed.

The Laboratory's expenditures and commitments for the academic year 1970-71 totalled $46 million, a decrease of approximately 8 per cent over the previous year. Laboratory personnel, including students, numbered 1,714 on June 1, a decrease of approximately 10 per cent over the previous June. A funding level of $42.8 million seems reasonably assured for the coming year. This would amount to a decrease of 7 per cent over the past year. However, it is anticipated that with reasonable success in having outstanding proposals accepted, the funding rate may remain at approximately the current level. This will, however, involve a reduction of personnel due to anticipated increases in salaries and wages. During the past year, 11 students com-

pleted graduate theses in the Laboratory that resulted in degrees. Some 349 students of all classes had significant education contacts with the Laboratory, while 124 staff members registered for subjects in the Institute.

Technological successes have continued at a high level for the Laboratory during the past year. Inertial sensor developments for third generation instruments have reached the stage of extended tests on engineering prototype units. First results show clearly that design performance objectives have been achieved or exceeded for both the gyro units and the specific force integrating receivers. Manufacturing information has been prepared and delivered to the sponsor for initiation of small quantity procurement from industrial companies interested in producing equipment.

System designs incorporating the new sensors are being completed and checked by working models in the Laboratory. It is expected that manufacturing information will be ready on schedule during about the next two years. It appears that both performance and reliability goals will be reached within this time period.

Operational tests of the Poseidon Fleet Ballistic Missile System and routine patrols with completely satisfactory results from guidance equipment have demonstrated the practical success of another system designed by the Laboratory.

Test dives with the Navy's Deep Submergence Submarine Rescue Vehicles during the past year have demonstrated that the control, navigation and integrated display systems designed by the Laboratory are operating satisfactorily. Equipment for the Navy's two rescue vehicles were designed, fabricated, tested, and integrated by the Laboratory. They provide the DSRV with the capability of mating with a distressed submarine and rescuing the crew.

Tests of the SABRE Systems already built for the Air Force have continued to demonstrate the soundness of the concepts involved and to provide ideas for incorporation into navigation, guidance and instrumentation equipment now being developed. These new technology developments, AIR and SIGHT programs will be smaller, lighter, have higher performance, greater reliability and be less expensive than existing hardware. The Laboratory is continuing with conceptual designs of systems and long lead hardware development efforts to serve various applications of already available technology to scientific and civilian problems.

A geometrical reference system designed and built for the Federal Aviation Administration, for use in SEAL (Signal Evaluation Airborne Laboratory) has completed the required series of tests and a final

report has been prepared. The equipment and the report have been delivered to the FAA. Discussions of possible continuation projects are now in progress.

Three stabilization and angular control systems for the Orbiting Astronomical Observatory of NASA have been designed, built, and delivered. One system was installed in a vehicle and was destroyed when the vehicle by which it was carried crashed on takeoff. The other systems have passed acceptance tests and are ready for use when vehicles are launched.

Control for vertical takeoff and landing aircraft has been the subject of continued research and development in the Laboratory by Mr. Ralph B. Trueblood, Professor Rene H. Miller, and Professor H. Philip Whitaker, under the sponsorship of the U.S. Army. Theory has been refined and checked by helicopter flight tests of engineering test models. This work continues and by applications of improved sensors and advanced mechanizations can be expected to realize very significant technological progress during the next year. Logical extensions of this work are seen in the area of civil short-haul VTOL transportation where application of the technology being developed can provide increased safety and more reliable operations under all-weather conditions. Drastic improvement in both of these factors is essential for the successful development of VTOL short-haul air transport systems able to operate from compact terminal areas.

APOLLO 14 with its problem of a defective switch sending abort signals to the guidance computer attracted attention to the Laboratory in spectacular fashion. The high-nervous-tension process of finding a "work around" procedure simple and sure in a very short time was dramatized by news media throughout the world. This certainly publicized the contributions of the Laboratory to guidance for spacecraft and made sure that the picture of Donald E. Eyles appeared prominently in the pages of many papers and magazines. Funding for NASA projects has decreased for the Laboratory but continues to represent an important part of total support for the group responsible for APOLLO work.

The activities of the Scientific Technology Division headed by Mr. Philip N. Bowditch have seen significant growth and expansion over the last year. This effort has concentrated mainly on the development of interactive and collaborative efforts with the scientific and academic interests both within and also outside of M.I.T.

During the year a major scientific lunar surface gravity experiment proposed by the Department of Earth and Planetary Sciences of M.I.T., the Lamont Doherty Laboratory of Columbia University, and the Draper

Laboratory was accepted and funded by NASA. This program is currently in the design and fabrication stage at the Laboratory and is scheduled for flight utilization on the APOLLO 17 lunar mission. In a similar vein the Laboratory is currently designing a major array of oceanographic sensors as a co-participant with the Department of Earth and Planetary Sciences of M.I.T. for an international mid-ocean dynamics experiment involving several other United States universities and oceanographic centers as well as British, Canadian, and other foreign participants. This program is being funded by the National Science Foundation and is scheduled for completion and field deployment in 1973.

Significant growth in the Laboratory's involvement with bio-medical engineering has been realized in the last year. With the appointment of Dr. Robert S. Lees, Director of M.I.T.'s Clinical Research Center, as a Visiting Associate Director of the Draper Laboratory, the Laboratory has expanded its role in automating clinical chemistry and developing the interactive use of computers with bio-medicine. At this juncture approximately four Laboratory senior staff personnel are engaged full-time with clinical research projects both at M.I.T. and other outside medical facilities.

One further effort involving industrial sponsorship is worthy of note. During the year the Draper Laboratory negotiated a contract with the FIAT SpA Corporation of Turin, Italy, to explore the adaptation of modern control theory to the problems of industrial process control. This activity has identified an approach to failure diagnosis which promises significant efficiency improvements in automated manufacturing processes. Further activities of an expanded scope are currently being negotiated.

A final example of Laboratory academic interaction is contained in the reestablishment this year of a fully accredited freshman oriented seminar offered during both fall and spring terms at M.I.T. This seminar has drawn heavily from the Scientific Technology Division's activities and has involved many numbers of the Laboratory staff in a teaching role. It is intended in the fall to expand this activity to a series of seminars and increased involvement of Laboratory staff instructors.

The above examples are indicative of the spectrum of the Laboratory's concern with scientific, academic, and industrial interests. This listing is not complete, but serves to show the many ways in which a laboratory of technology can support and derive benefit from interactions with the scientific, academic, and industrial communities.

Faculty members of the Department of Aeronautics and Astronautics have continued to provide general direction for Laboratory activities and to incorporate information and experience derived from develop-

ments of advanced technology into the body of engineering education. Institute Professor Emeritus Draper continued to serve as the President of the Laboratory with Professor Walter Wrigley as Educational Director. Department faculty members associated with Professor Wrigley in academic activities included Professors Renwick Curry, John J. Deyst, Shaoul Ezekiel, Robert L. Halfman, Walter M. Hollister, Albert L. Hopkins, Jr., Yao T. Li, Winston R. Markey, Walter McKay, Robert K. Mueller, James E. Potter, Wallace E. Vander Velde, H. Philip Whitaker, and Laurance R. Young. From the Laboratory staff, Doctors Richard H. Battin, Robert G. Stern, and Mr. Phillip N. Bowditch served as Lecturers, taking the responsibility for teaching subjects in Aeronautics and Astronautics. Roger B. Woodbury, Forrest E. Houston, and Ralph R. Ragan continued to serve as Deputy Directors, with Joshua B. Feldman as Executive Officer.

CHARLES STARK DRAPER
ALBERT G. HILL

LINCOLN LABORATORY

The past year has seen some modest but encouraging innovations in Lincoln liaison with academic activities and in the development of sponsorship from civilian sources.

The two-way flow between the Laboratory and the campus was marked this year by a greater variety of educational activities involving Lincoln staff members, faculty, and students.

As in past years, M.I.T. faculty members and students performed research at Lincoln Laboratory in collaboration with staff members. The process was facilitated for students by provisions for special access privileges and transportation between Cambridge and Lexington. Many of these students engaged in thesis research under the direction of Lincoln staff members, and the Laboratory continued to provide support for graduate students in the form of research assistantships.

Freshman seminars were given in radar astronomy, design of large radio telescopes, and satellite communications. Nine research projects were offered as part of the Undergraduate Research Opportunities Program of the Education Research Center. During the Independent Activities Program, 12 students worked with Lincoln staff members in four programs: explosions and earthquakes, air traffic control, interaction graphics, and microelectronics. More than 100 students visited Lincoln Laboratory for talks on Laboratory programs and tours of Laboratory facilities.

Three senior faculty members are now serving as Head or Associate Head of technical divisions at Lincoln. Conversely, 43 Lincoln staff members taught classes or gave lectures at M.I.T. during this academic year, and there are 27 former Lincoln staff members on the M.I.T. faculty.

The Standing Committee on Special Laboratories held four meetings during the year, three to review Lincoln technical programs and one focused on increasing student and faculty interactions with the Laboratory; these meetings were generally helpful, stimulating, and harmonious.

Considerable effort has been expended in recent years to search out ways in which the Laboratory's established skills can serve civilian as well as defense needs and to broaden the base of Laboratory sponsorship. There have been a number of encouraging developments along these lines this year.

The Environmental Protection Agency is now funding a program to develop new methods for the detection, identification, and measurement of air pollutant gases using infrared spectroscopic techniques made possible by tunable diode lasers developed previously under our Air Force-sponsored solid state program. Particular effort is focused on the heterodyne detection of sulfur dioxide in smoke plumes at a distance, but the unprecedented resolution of spectra obtained with diode lasers also makes possible the positive identification of many other gaseous species, singly or in combinations.

At the beginning of the year, our work in air traffic control had a staff of 10 and received all its fiscal support from the Air Force. Supplementary funding during the year has been received from four civilian agencies, one state and three Federal, and the staff has now increased to 28, with about half of the support coming from non-defense sources. One aspect of this work is the development and evaluation of a display in the cockpit to assist the pilot in assessing the situation of his aircraft with respect to navigation aids and to other aircraft in his vicinity. Simulation of the performance of such a display has been a joint effort with the Electronic Systems Laboratory, on campus, with some Lincoln participation and funding.

Educational technology, another relatively new project, is aimed at the development of equipment and techniques for self-paced instruction that will reduce the time required for a group of students to reach a definable level of technical capability and thus reduce the cost of instruction. This objective is doubly attractive in the case of on-the-job training, where this cost includes students' pay during the instruction period. The Air Force trains large numbers of personnel in the operation and maintenance of a wide variety of mechanical and electronic

equipment; our program is sponsored by the Air Force, although the results could have considerable importance for industrial vocational training and for special areas of public education (for example, speech therapy, remedial reading, and education of the retarded) where tutorial requirements are especially costly. The necessary equipment should be economical to produce and operate; the lesson material should be easy to handle and economical to reproduce and distribute; the system should produce high quality visual displays for text, diagrams, and photographs and accompanying voice commentary to reinforce written text or audio demonstrations; the branching and control logic should be versatile and natural enough to stimulate and hold the student's interest, and some record of the students' progress should be maintained, without requiring the services of a large computer. With close cooperation from the Keesler Technical Training Center, we are now developing facilities and educational materials for field tests with Air Force personnel in two subject areas, principles of electronics and air traffic control, that are parts of their regular curriculum.

Renewed funding of our ambulatory health care program by the Department of Health, Education, and Welfare, at a rate which approximately doubles the size of the program in its initial phase, took effect in January for a period of 16 months. This effort centers on the codification of certain aspects of medical practice into a form that permits a medical aide with very little special training, guided by a computerized protocol, to handle a significant number of patient-visits safely and effectively without the personal intervention of a physician unless one is actually needed. This work is being carried out jointly with the Beth Israel Hospital, where protocols for the management of chronic diabetes and hypertension are undergoing preliminary tests.

Also during the past year, we have participated in the design and development of an educational television satellite system for India with support from the Ford Foundation, carried out radio propagation measurements relevant to the influence of weather phenomena on satellite communications systems for NASA at the request of the President's Office of Telecommunications Policy, performed studies of reentry phenomenology for the Arms Control and Disarmament Agency in support of the SALT talks, and completed a demonstration of information retrieval techniques for the National Library of Medicine.

Although they seem to augur well for increasing support from civilian agencies in the years ahead, the programs mentioned above are a small fraction of the Laboratory's total effort. Our major program areas continue to be Communications, with support from the Air Force and the Navy, and Strategic Technology, with support from the Air Force,

the Army, and the Advanced Research Projects Agency (ARPA). Other current programs include Advanced Electronic Technology and Radar Techniques (Air Force) and Graphics and Seismic Discrimination (ARPA). The year has seen two major shifts of emphasis in these programs.

In Satellite Communications, the next Lincoln Experiment Satellite, LES-7, was being designed to operate at X-band with multiple, steerable beams for selective coverage of various parts of the earth's surface. We are carrying through to completion the development of certain key elements of LES-7, notably a waveguide lens assembly for beam-forming, but the actual construction of LES-7, has been set aside. Instead, we have turned our attention to a pair of satellites, LES-8 and -9, with special capabilities for inter-satellite communication. LES-8 and -9 will differ from any of our previous satellites in several respects: they will be considerably larger and heavier; they will be powered by radioisotope thermoelectric generators instead of solar cells; and they will be three-axis-stabilized instead of spinstabilized. Cross-link communications between the satellites will be at optical and EHF wavelengths. Launch is scheduled for 1974.

The second significant shift of emphasis is the radar measurements program that is part of our work on strategic technology. For several years, this program has been concentrated on the measurement, analysis, and interpretation of physical phenomena associated with missile re-entry, using the TRADEX, ALTAIR and ALCOR radar systems at the Kiernan Reentry Measurements Site (KREMS) on Kwajalein. The objective of this effort has been to identify measureable phenomena that can be used to distinguish a warhead from fuel tanks, decoys, and other objects that may accompany it. Our new objective is to reduce the measurement, analysis, and interpretation process to real-time operation for field experiments. Its achievement calls for a large-scale computer programming effort, the installation of two large new computer systems, one at the Laboratory and one at KREMS, modifications to existing KREMS radar systems, and the development of control and interface equipment to merge the radars and computer systems. Field tests are scheduled to start in 1973.

There have been no major organizational changes in the Laboratory, and only two major appointments: William Z. Lemnios was appointed Associate Head of the Radar Measurements Division, and Paul Rosen was appointed Associate Head of the Engineering Division. By way of contrast, all three members of the Air Force Joint Advisory Committee for Lincoln Laboratory have been replaced: the new members are its Chairman, Gen. G. S. Brown, Commander, Air Force Systems Com-

mand; Lt. Gen. W. C. Gribble, Jr., Chief of Research and Development, U.S. Army; and Dr. S. J. Lukasik, Director, Advanced Research Projects Agency. This committee provides overall policy and program guidance to the Laboratory in relation to its defense programs.

In closing I would note that major effort was required this year to preserve the financial support that permits Lincoln Laboratory to maintain stability of operation. Nationally, research and development funding by civilian agencies of government has not kept pace either with the rapidly increasing appropriations for some of these agencies or with cutbacks in defense funding. Defense funding was further restricted by the elimination of all but so-called "mission-oriented" research. I think it speaks well for the Laboratory's reputation with its sponsors and for the dedication and hard work of its members that these funding problems have had a minimum effect on the size and vigor of the Laboratory.

GERALD P. DINNEEN

DIVISION OF SPONSORED RESEARCH

During the past year, the evaluation of M.I.T. research policies and programs continued within the Institute community, but in a calmer atmosphere than existed during the prior year. Giving further impetus to this reappraisal was the report of the Commission on M.I.T. Education, "Creative Renewal in a Time of Crisis." In the section dealing with research policy at M.I.T., the report states that:

> In the face of the changing role of technology in society, which is already reflected in the changing pattern of government funding, it may be necessary to reexamine the research habits of the MIT community. As the Lewis Committee noted twenty years ago:
> '. . . the scope and character of sponsored research at MIT is, in effect, the aggregate of the voluntary actions of MIT faculty members, and the faculty has primary responsibility for sponsored research policy as an integral part of its broader responsibilities for educational policies and practices. This responsibility can be discharged best under policies enunciated by the faculty for the guidance of departments and schools, but success in avoiding the dangers and pitfalls of a large-scale sponsored research program will require eternal vigilance and wisdom by our top administration.'
> The Lewis Committee's timely warning has unfortunately not been taken seriously enough by the faculty. Too much of the burden of responsibility has been placed on the shoulders of the administration. We believe that the faculty should face up to its responsibilities in the area of research as well as in relation to graduate education.

The problems the faculty must face in connection with research policy were described in the report of the Commission's Working Group on

Academic Research Policy. Referring to these, the Commission suggests that the formulation of general guidelines might be useful both to the Institute and individual faculty members, particularly if a mechanism were established to advise the administration and faculty on their application. To provide such a mechanism the Commission recommends that the Committee on Educational Policy become the principal instrument for the formulation of faculty policy concerning research as well as education.

The need for such a mechanism is especially acute in view of the increasing importance of interdisciplinary research. Among the interdisciplinary studies of present importance are health science and technology, environmental science and engineering, urban engineering, and technological policy. These fields and others will demand the establishment of new organizational structures and, because the new organizations will have to cross departmental lines, their establishment will require the formulation of new educational policies. Developing such policies will take time and effort, but in our view the faculty can avoid this job only at its own risk.

NEW RESEARCH LABORATORIES

Of the new research laboratories and faculties established during the year, three in particular demonstrate the breadth of M.I.T. research activities.

In January, the Artificial Intelligence Laboratory was formally established as a separate entity headed by Professor Marvin Minsky, Department of Electrical Engineering, and Professor Seymour Papert, Department of Mathematics. The group, active in artificial intelligence and heuristic programming since 1958, was first part of the Research Laboratory of Electronics, then the Computation Center, and in 1963 became a part of Project MAC. The central concerns of the laboratory are with the development of theories of problem-solving and other general principles of intellectual activities for both machines and organisms.

Late in the year, the National Heart and Lung Institute of NIH approved the Institute's application for an interdisciplinary M.I.T. Arteriosclerosis Center to be directed by Dr. Robert S. Lees, Associate Professor of Metabolism and Human Nutrition and Director of the Clinical Research Center. The experimental and theoretical program will use the facilities of the Clinical Research Center and the Fluid Mechanics Laboratory in the Department of Mechanical Engineering. Two major goals of arteriosclerotic research at M.I.T. are, first, to develop fast, safe and inexpensive methods for determining the presence and extent of the disease before its clinical symptoms appear and, second, to find treatments for the disease which will stop and hopefully reverse its progress.

By the end of the year, the Haystack Observatory, one of the most versatile radio astronomy centers in the world, had been turned over to M.I.T. by the Air Force and was being operated by the Institute on behalf of the Northeast Radio Observatory Corporation (NEROC), a nonprofit consortium of 13 educational and research organizations of which M.I.T. is a leading member. The Haystack facility was designed in 1959 as a Department of Defense project in satellite communications and microwave research to be operated by Lincoln Laboratory. Since then technological developments have made stations like Haystack unnecessary for satellite communications and it has been used increasingly in recent years for radio and radar astronomy.

RESEARCH VOLUME

The total volume of sponsored research performed in fiscal 1971 by academic departments and interdepartmental laboratories and administered by the Division totaled $61.756 million, compared with $58.125 million in 1970 and $55.813 in 1969. The 1971 increase, however, includes roughly $1.4 million in subcontracting on space flight experiments conducted by the Center for Space Research. Those subcontracts aside, on-campus volume for 1971, in terms of "real growth," declined due to inflation. The current fiscal 1972 forecast, discounting subcontracts of $4.6 million, reflects an increase which, if realized, would be the first "real growth" in four years.

Of the total fiscal 1971 sponsored research volume, approximately $10.0 million was funded from non-Federal sources, compared with $6.8 and $8.6 million in 1969 and 1970, respectively. Foundations and other non-profit organizations provided $6.6 million and industrial companies supported $1.8 million in research through grants-in-aid and contracts.

FEDERAL RESEARCH SUPPORT

Last year we were particularly concerned over the combined effects of Department of Defense budget reductions and the Mansfield amendment on major programs at M.I.T., including those underway at the National Magnet Laboratory, the Research Laboratory of Electronics and the Center for Materials Science and Engineering. The over-all level of DOD support in the current year, however, is down only slightly from 1970.

In this connection, it would now appear that the principal impact of the Mansfield amendment has already been felt. The language of the 1970 military procurement authorization bill restricted DOD research support to projects having "a direct or apparent relationship to a specific military function or operation." According to DOD, this resulted in the

dropping of $8.8 million in DOD-sponsored research projects at academic institutions.

The language in the 1971 authorization bill, however, restricts DOD research support to those projects which have "in the opinion of the Secretary of Defense a potential relationship to a military function or operation."

In addition, the decision has been reached that the National Science Foundation rather than the Air Force will hereafter provide support to the National Magnet Laboratory, and the NSF budget for fiscal 1972 contains $1.8 million for that purpose.

Taking this transfer into account, the current forecast of DOD support in fiscal 1972 is for the same level as 1971. It also seems likely that NSF will in fiscal 1973 assume responsibility for the materials research program, now funded by ARPA, which provides the core support of the Center for Materials Science and Engineering. Although the level of research support for these laboratories has been reduced, they nonetheless appear to be making the transition from DOD to NSF successfully.

The decline of AEC support for academic science continues to put extreme pressure on programs of the Laboratory for Nuclear Science and the Harvard-M.I.T. Cambridge Electron Accelerator, and is expected to continue in fiscal 1972.

HEW, NSF and NASA support, on the other hand, will in fiscal 1972 increase significantly over the level of 1971, even allowing for $4.2 million in subcontracting on flight experiment programs and the transfer to NSF of National Magnet Laboratory sponsorship.

STUDENT SUPPORT PROGRAMS

In fiscal 1971, approximately 600 fellows and trainees at M.I.T. received $3.2 million in Federal support independent of specific research projects. As a result of the Administration's decision to reduce federal support for training in science and engineering, the number of M.I.T. students receiving this type of support during academic 1971-72 will decrease by approximately 120.

The Administration's 1972 budget proposals for other Federal student aid programs would ensure that Federal funds go first and in the largest amounts to the neediest students through a combination of grants, work-study payments and Federally insured loans. During hearings on the legislation which embodies these proposals, members of the House Special Subcommittee on Education were critical because there was no aid provided for middle income students, no new appropriations for the popular NDEA direct loan program, and no funds for general institutional operating support.

Several members of the Congress have therefore filed bills of their own to provide support in these areas not covered by the Administration, and the Administration has responded by disclosing its own general aid proposal for colleges and universities.

D.S.R. ADMINISTRATION

During the year we have given increased attention to defining the functions of the Division and the specific responsibilities of its personnel. Of major importance was the appointment of Francis H. McGrory as Associate Director effective January 1, 1971. His principal assignment is coordination of those activities of the Division which relate to the School of Science, particularly those involving the submission of research proposals, negotiation of grants and contracts, and administration of sponsored projects. In this capacity, his duties will closely parallel and reinforce certain of his part-time responsibilities as Administrative Officer of the School of Science, an additional position to which he was appointed in 1969 while serving as an Assistant Director in D.S.R.

There are a number of ways in which we intend to further modify and strengthen the Division in the months ahead, such as improving mechanisms for the administration of broad interdisciplinary and interinstitutional programs and updating and clarifying a number of research policies and procedures. In addition, we have already undertaken a significant reorganization of the D.S.R. Patent Section, which will result in a reduction from nine to three in-house patent attorneys by next fall.

This reduction in the patent staff is based in part on budgetary considerations since we have concluded that an in-house function is more costly than the use of outside attorneys. A more substantive goal of the reorganization, however, is to ensure that the filing of patent applications will to a greater degree reflect a judgement as to the commercial potential of the inventions involved.

We have, therefore, established several mechanisms through which the D.S.R. Patent Section will interact more effectively with the separate Office of Patent Administration. This office is responsible for the licensing of M.I.T.-owned inventions and will report to the D.S.R. Director effective July 1, 1971. In addition, to gain broader expertise and a shorter response time, we will expand the use of outside patent attorneys as needed.

GEORGE H. DUMMER

VICE PRESIDENT AND TREASURER

In 1970-71 funds were provided to meet the operating expenses of the Institute, to finance a substantial program of student aid, to finance further building construction, and there was a large addition to the endowment capital of M.I.T. This satisfactory result was made possible by drawing heavily on unrestricted funds including funds accumulated in earlier years, by increased revenues for operations from tuition and endowment income, by total operations being sustained at very near the level of 1969-70, and by the constructive gifts, grants, and bequests received from generous donors to M.I.T.

In common with many private universities, M.I.T. faces a widening gap between revenues and expenses, and in 1970-71 $4,907,000 of unrestricted resources were required to close this gap. In 1969-70 $4,636,000 of unrestricted resources were similarly required, $2,203,000 in 1968-69, and $841,000 in 1967-68. These unrestricted resources consist of gifts and grants, patent revenues, and reimbursement for the use of the Institute's plant and equipment by sponsored research.

The direct expenses of instruction and departmental sponsored research continued to rise in 1970-71 but the corresponding expenses of the special sponsored research laboratories declined, due primarily to reduced subcontracts to outside organizations. With the leveling off of sponsored research, more of the total operating expenses of the Institute had to be carried by private sources of funding.

GIFTS

Gifts, grants, and bequests received in 1970-71 were higher than in any recent year except 1965-66.

	1970-71	1969-70
Gifts for endowment	$ 3,863,000	$ 1,853,000
Gifts for buildings	2,515,000	3,918,000
Gifts for current use — invested	24,215,000	4,453,000
Industrial Liaison Program	1,405,000	1,648,000
Other funds for current use	3,593,000	4,006,000
Total gifts to funds	**$35,591,000**	**$15,878,000**
Grants-in-aid	4,046,000	3,743,000
Total	**$39,637,000**	**$19,621,000**

The increase in gifts, grants, and bequests for the year 1970-71 reflected the receipt of the remainder of the legacy of K. Dexter McCormick. The further distribution from the estate of Leonard D. Lawrence together with the bequest from the estate of Mrs. McCormick contributed substantially in 1970-71 to Gifts for current use — invested. During the year, a portion of the land in Truro, Massachusetts, bequeathed to M.I.T. in 1937 by Dr. Francis H. Williams was sold to the government to be included in the Cape Cod National Seashore. The proceeds of the sale provide an addition to The William Barton Rogers and Emma Savage Rogers endowment fund for research in pure science. Endowment for professorships were an important part of the gifts received in 1970-71. A large gift for the health science program was received, and there were major gifts for educational and research facilities and research funding. Unrestricted gifts of $1,010,000 are included in the total of $2,564,000 reported by the Alumni Fund in 1970-71.

FUNDS

The total book value of the funds of the Institute on June 30, 1971 was $328,247,000 compared with $302,901,000 on June 30, 1970.

	1970-71	1969-70
Endowment funds:		
For general purposes	$ 73,479,000	$ 58,277,000
For designated purposes	104,164,000	100,238,000
Net realized gain from investments	38,721,000	31,386,000
Total endowment funds	**$216,364,000**	**$189,901,000**
Building and expendable funds	75,084,000	77,612,000
Other funds	36,799,000	35,388,000
Total funds	**$328,247,000**	**$302,901,000**

The increase in total endowment funds in 1970-71 was due primarily to the addition to Endowment for general purposes of the greater part of the final receipt from the estate of Mrs. McCormick. There were transfers of funds functioning as endowment to the expendable and other fund groups but these reductions were more than offset by additions to the endowment funds from gifts and bequests. The net realized gain on the general investments during the year was $7,650,000 compared with $3,979,000 in 1969-70.

Investment income for distribution to funds was $20,272,000 on June 30, 1971, and $19,447,000 on June 30, 1970. The Research Reserve for the long-term partial funding of tenure salaries of faculty increased from $9,380,000 to $9,849,000 due to the investment income earned by and allocated to the fund in 1970-71. The further increase in Inventories, deferred charges and other assets to $14,019,000 caused in part the increase to $6,556,000 in temporary financing through the use of invested funds. Special cash advances for Institute purposes are included in Other assets, and reserves cover a part of the total advances outstanding.

PLANT

The book value of the educational plant of the Institute increased to $143,120,000 on June 30, 1971, from $136,926,000 on June 30, 1970. Additions to the educational plant during the year included the virtual completion of the renovation of Burton-Conner House, the initial construction of Westgate II, The George R. Wallace, Jr., Astrophysical Observatory in Westford, Massachusetts, the J. B. Carr Indoor Tennis Center, and the Electrical Engineering and Electronics Complex.

Westgate II will be built largely with funds received from the Massachusetts Health and Educational Facilities Authority which will own the property, leasing it to the Institute for 30 years, after which full title reverts to M.I.T. In November 1970 the Authority acquired the funds for Westgate II through an issue of publicly offered tax exempt bonds maturing from 1972 to 2002 and secured by the lease between the Authority and M.I.T. and a pledge of general revenues. The greater part of the cost of the heating and chilled water plant facilities, started in 1970-71, was included in a similar transaction with the Authority but with a 25 year term to recognize the useful life of these facilities.

As of June 30, 1971 approximately 10 per cent of the book value of the plant was financed by loans from private and government sources. The total mortgage indebtedness of $14,161,000 consists of $11,276,000 of Federal government loans and $2,885,000 of other loans. Temporary advances from current resources for construction totaled $4,648,000 on June 30, 1971, and $6,436,000 on June 30, 1970.

INVESTMENTS

The year-to-year change in endowment and other investments of the Institute was marked by the recovery in values in the market for common stocks and bonds.

	June 30, 1971		June 30, 1970	
	Book Value	Market Value	Book Value	Market Value
General investments:				
Fixed income	$142,077,000	$129,341,000	$141,789,000	$120,464,000
Equities	87,287,000	174,479,000	81,229,000	125,298,000
Real estate:				
For present or future Institute use	15,627,000	15,627,000	13,823,000	13,823,000
Other real estate	30,057,000	33,624,000[1]	23,953,000	31,143,000[1]
Total	**$275,048,000**	**$353,071,000**	**$260,794,000**	**$290,728,000**
Separately invested	28,239,000	29,468,000	17,660,000	17,363,000
Students' notes receivable	12,889,000	12,889,000	12,239,000	12,239,000
Total	**$316,176,000**	**$395,428,000**	**$290,693,000**	**$320,330,000**

[1]At values determined by professional appraisers

Although common stocks at market values on June 30, 1971, were approximately one-half of the general investments, they represented about two-thirds of the endowment investments included within the total of general investments. In addition, the greater part of the real estate investments are equity commitments.

The total income on the investment portfolio was $15,498,000 compared with $15,523,000 in the preceding year. The general investment income distributed to funds was $15,356,000 in 1970-71 compared with $14,209,000 in 1969-70, including therein an increase in the use of endowment income for operations of $8,435,000 in 1971, up from $7,354,000 in 1969-70. The endowment portfolio includes real estate investments yet to be developed into earning assets which resulted in a loss in current endowment income in 1970-71. Certain real estate investments in Cambridge require installment payments over a period of years as part of the plan of financing these acquisitions.

RETIREMENT FUNDS

The investments of the M.I.T. Pension Association, the Supplementary Retirement Plan, and the Retirement Plan for Employees on June 30, 1971, and June 30, 1970, are presented in the following exhibit. This is exclusive of reserves in excess of $5,300,000 held by a life insurance

company to provide certain benefits under the Retirement Plan for Employees.

	June 30, 1971		June 30, 1970	
	Book Value	Market Value	Book Value	Market Value
Pension Association	$ 53,370,000	$ 54,896,000	$ 49,104,000	$44,189,000
Supplementary Retirement Plan — Fixed Benefit	28,657,000	26,821,000	25,676,000	21,380,000
Supplementary Retirement Plan — Variable Benefit	13,650,000	15,399,000	11,376,000	9,501,000
Retirement Plan for Employees	25,463,000	23,414,000	22,431,000	17,495,000
Total	**$121,140,000**	**$120,530,000**	**$108,587,000**	**$92,565,000**

While the retirement plan investments are not a part of the financial assets of the Institute, $7,293,000 of M.I.T. pension expense was included in operations in 1970-71. During the year, improvements in retirement and other benefits were implemented. Consulting actuaries conducted a thorough evaluation of the staff retirement plan for the trustees of the retirement funds in 1970-71.

GENERAL

Officers of the financial administration presented detailed reports on the finances of the Institute at six of the monthly meetings of the Executive Committee during the year. These reports included projections of the operations of the Institute over a three-year period and plans for the allocation of resources to student aid and to capital needs. Further steps were taken in 1970-71 and in planning the 1971-72 budget to moderate the growth in expenses and to more closely match the operating expenses of the Institute with the available resources.

The student loan funds of M.I.T. were supplemented with funds borrowed from banks during the year but this is a source of limited availability so that new sources of student loan capital need to be developed. The Federal loan programs, although expanded, have not been adequate to meet the needs of the students. Graduate student fellowships are being further curtailed by the Federal agencies leading to a critical requirement for this kind of student aid at the Institute. Endowed and other undergraduate scholarships continue to increase but do not meet the growth in need of the students. It may be necessary to advance some part of the

unallocated investment income to endowed scholarships in the years immediately ahead.

To provide for public housing, the Cambridge Housing Authority, supported by the Department of Housing and Urban Development, contracted to purchase from M.I.T. three sites in Cambridge and the buildings to be constructed thereon under M.I.T. auspices in the amount of over $17,000,000. This is a major step in the program initiated by the Institute more than five years ago that will effectively increase the housing stock in the community.

JOSEPH J. SNYDER

Schedule A: SOURCES OF REVENUES AND FUNDS USED TO MEET EXPENSES OF CURRENT OPERATIONS

FOR THE YEARS ENDED JUNE 30, 1971 AND 1970

	1971	1970
OPERATING EXPENSES		
Instruction and unsponsored research	$ 27,918,000	$ 25,134,000
Sponsored research:		
Direct costs:		
Departmental and interdepartmental	49,015,000	46,409,000
Lincoln Laboratory	52,778,000	58,342,000
Draper Laboratory	34,454,000	40,787,000
Research vacation expense	4,139,000	3,754,000
Research administration and general expenses	1,562,000	1,539,000
Total expenses directly attributable to instruction and research	$169,866,000	$175,965,000
Costs applicable to both instruction and research:		
Libraries	3,030,000	2,714,000
Medical	2,160,000	1,817,000
Plant operation and maintenance	12,384,000	10,923,000
Administration	2,621,000	2,230,000
Fiscal, personnel & other Institute-wide services	7,518,000	6,981,000
General expenses	2,066,000	2,722,000
Other instruction and research support activities	2,718,000	2,747,000
Student services	4,368,000	3,866,000
Auxiliary activities	7,162,000	6,878,000
	$213,893,000	$216,843,000
REVENUES AND FUNDS USED		
Tuition and other income	$ 21,548,000	$ 19,036,000
Research revenues:		
Departmental and interdepartmental	60,892,000	57,013,000
Lincoln Laboratory	58,604,000	64,091,000
Draper Laboratory	43,933,000	50,190,000
Appropriation of indirect expense allowance for use of facilities	(1,209,000)	(1,423,000)
Auxiliary activities	7,162,000	6,878,000
Endowment investment income (Note A):		
Total income received from investments	15,498,000	15,523,000
Distributed to building and other invested funds	(3,814,000)	(4,752,000)
Distributed to endowment funds	11,684,000	10,771,000
Used for scholarships and fellowships	(1,686,000)	(1,562,000)
Added to unexpended balances and transferred to other funds	(1,563,000)	(1,855,000)
Used for operations	8,435,000	7,354,000
Gifts, investment income, and other receipts for designated purposes	9,621,000	9,068,000
Unrestricted funds used to meet operating expenses	4,907,000	4,636,000
	$213,893,000	$216,843,000

The accompanying notes are an integral part of the financial statements.

Schedule B: **BALANCE SHEETS, JUNE 30, 1971 AND 1970**

ASSETS

CURRENT FUND ASSETS	1971	1970
Cash:		
General purposes	$ 1,723,000	$ 2,023,000
Restricted, principally to research activities	4,482,000	2,710,000
Accounts receivable:		
U.S. Government	3,798,000	7,211,000
Other	4,660,000	4,217,000
Contracts in progress, principally U.S. Government	18,955,000	14,976,000
Inventories, deferred charges and other assets	14,019,000	12,480,000
Due to invested funds	(6,556,000)	(4,877,000)
	$ 41,081,000	**$ 38,740,000**
INVESTMENTS (Note A)		
General investments, at cost:		
Fixed income	$142,077,000	$141,789,000
Equities	87,287,000	81,229,000
Real estate (including $15,627,000 — 1971 and $13,823,000 — 1970 for present or future Institute use)	45,684,000	37,776,000
	$275,048,000	$260,794,000
Investments of separately invested funds, at cost	28,239,000	17,660,000
Students' notes receivable	12,889,000	12,239,000
Total investments	$316,176,000	$290,693,000
Cash held for investment	34,000	882,000
Receivables (payables) arising from investment transactions	1,835,000	(1,036,000)
Due from current funds	6,556,000	4,877,000
	$324,601,000	**$295,416,000**
EDUCATIONAL PLANT		
Land, buildings and equipment, at cost	$142,663,000	$135,594,000
Construction in progress	290,000	551,000
Temporary investments and cash	167,000	781,000
	$143,120,000	**$136,926,000**
	$508,802,000	**$471,082,000**

The accompanying notes are an integral part of the financial statements.

LIABILITIES AND FUNDS

CURRENT FUNDS	1971	1970
Accounts payable and accruals	$ 13,769,000	$ 10,975.000
Withholdings, deposits and other credits	4,271,000	4,364,000
Advances by the U.S. Government for certain research contracts and grants	18,649,000	18,984,000
Unexpended grants for sponsored research from private sources	2,147,000	1,953,000
Gifts and other receipts available for current expenses	6,893,000	8,900,000
Due from educational plant fund	(4,648,000)	(6,436,000)
	$ 41,081,000	**$ 38,740,000**
INVESTED FUNDS		
Endowment funds (Note A):		
Income for general purposes	$ 73,479,000	$ 58,277,000
Income for designated purposes	104,164,000	100,238,000
Net realized gain from investments	38,721,000	31,386,000
Student loan funds (Note B)	12,002,000	11,562,000
Building funds	14,851,000	11,707,000
Other expendable funds:		
General purposes	.....	3,220,000
Designated purposes	48,715,000	49,215,000
Unexpended endowment income for designated purposes	4,625,000	4,570,000
Agency funds	558,000	617,000
Funds subject to life interests in income	3,967,000	3,762,000
Investment income for distribution to funds	20,272,000	19,447,000
	$321,354,000	$294,001,000
Notes payable — student loans	1,124,000	514,000
— investment real estate	2,123,000	901,000
	$324,601,000	**$295,416,000**
EDUCATIONAL PLANT FUNDS		
Mortgage bonds and notes payable (Note C)	$ 14,161,000	$ 13,086,000
Due to current funds	4,648,000	6,436,000
Funds used for educational plant	124,311,000	117,404,000
	$143,120,000	**$136,926,000**
	$508,802,000	**$471,082,000**

Schedule C: STATEMENT OF FUNDS

FOR THE YEAR ENDED JUNE 30, 1971

	Balance June 30, 1970	Gifts and Other Receipts
Endowment funds (Note A):		
Income for general purposes	$ 58,277,000	$ (88,000)
Income for designated purposes	100,238,000	4,057,000
Net realized gain from investments	31,386,000	7,650,000
Student loan funds (Note B)	11,562,000	1,064,000
Building funds	11,707,000	2,516,000
Other expendable funds:		
General purpose	3,220,000	20,613,000
Designated purposes	49,215,000	5,852,000
Unexpended endowment income for designated purposes	4,570,000	.....
Agency funds	617,000	82,000
Funds subject to life interests in income	3,762,000	265,000
Investment income for distribution to funds	19,447,000	4,000
Current year's general investment income	.....	.....
Total invested funds	**$294,001,000**	**$42,015,000**
Gifts and other receipts available for current expenses	8,900,000	11,883,000
	$302,901,000	**$53,898,000**

Gifts and bequests received during the year added to funds	$35,591,000
Royalties received net of related costs	1,058,000
Receipts from foundations and agencies for student aid	4,787,000
Net gain on sales or exchanges of investments	7,598,000
Appropriations from research contract allowances	1,209,000
Government student loan support	874,000
Fees, services and other receipts	2,781,000
	$53,898,000

Endowment investment income used to meet expenses of current operation .....
Gifts, investment income and other receipts used to meet expenses of current operation .....

Scholarship and fellowship awards for tuition and stipends .....
Expenditures for buildings added to educational plant .....
Expenditures of service activities and other charges to funds not representing operating expenses
Operating expenses recorded in direct expenses of the Division of Sponsored Research .....

The accompanying notes are an integral part of the financial statements.

Investment Income (Note A)	Transfers In-(Out)	Expenses	Other Charges	Balance June 30, 1971
$ 4,480,000	$15,244,000	$ 4,434,000	.....	$ 73,479,000
*	(131,000)	.....	.....	104,164,000
525,000	(825,000)	.....	$ 15,000	38,721,000
13,000	(14,000)	40,000	583,000	12,002,000
515,000	6,730,000	396,000	6,221,000	14,851,000
298,000	(21,404,000)	2,517,000	210,000	.....
2,492,000	(868,000)	4,283,000	3,693,000	48,715,000
6,679,000	(1,283,000)	4,001,000	1,340,000	4,625,000
32,000	(156,000)	.....	17,000	558,000
168,000	(68,000)	.....	160,000	3,967,000
(15,356,000) 971,000	525,000 14,681,000	.....	.....	20,272,000
14,681,000	(14,681,000)	.....	.....	.....
$15,498,000	**$(2,250,000)**	**$15,671,000**	**$12,239,000**	**$321,354,000**
.....	2,250,000	7,293,000	8,847,000	6,893,000
$15,498,000	.....	**$22,964,000**	**$21,086,000**	**$328,247,000**

.....	$ 8,435,000
.....	14,529,000
	$22,964,000

.....	$ 7,999,000
.....	6,513,000
.....	3,705,000
.....	2,869,000
	$21,086,000

*Investment income on endowment funds for designated purposes is included under the caption "Unexpended endowment income for designated purposes."

Schedule D: SUMMARY OF CHANGES IN FUNDS

FOR THE TEN YEARS ENDED JUNE 30, 1971

(In thousands of dollars)

	1971	1970	1969
Fund balances at beginning of year	**$302,901**	**$290,598**	**$259,882**
Sources of funds:			
Gifts and bequests	$ 35,591	$ 15,878	$ 25,069
Investment income (Note A)	15,498	15,523	14,579
Net gain on sales or exchanges of investments	7,598	6,768	14,068
Royalties received net of related costs	1,058	963	1,772
Receipts from foundations and agencies for student aid	4,787	4,441	4,624
Appropriations from research contract allowances	1,209	1,698	1,405
Government construction grants	.....	92	2,188
Government grant for student loans	874	556	639
Fees, services and other receipts	2,781	3,141	2,921
	$ 69,396	$ 49,060	$ 67,265
Use of funds:			
Used to meet expenses of current operation:			
Endowment investment income (Note A)	$ 8,435	$ 7,354	$ 7,351
Gifts, investment income and other receipts	14,529	13,704	10,344
Scholarship and fellowship awards for tuition and stipends	7,999	7,533	7,279
Additions to educational plant	6,513	4,283	7,067
Operating expenses recorded in direct expenses of the Division of Sponsored Research	2,869	2,627	1,957
Other charges to funds not related to current operation	3,705	1,256	2,551
	44,050	36,757	36,549
Net increase in funds	25,346	12,303	30,716
Fund balances at end of year	328,247	302,901	290,598
Less gifts and other receipts available for current expenses	6,893	8,900	7,775
Total invested funds	**$321,354**	**$294,001**	**$282,823**

The accompanying notes are an integral part of the financial statements.

1968	1967	1966	1965	1964	1963	1962
$239,902	**$229,119**	**$190,722**	**$173,910**	**$150,008**	**$134,875**	**$122,657**
$ 22,147	$ 16,019	$ 39,186	$ 21,690	$ 20,221	$ 17,479	$ 17,691
13,502	12,788	10,455	9,482	8,039	7,245	6,581
9,221	3,008	5,153	3,155	4,328	3,874	37
698	709	519	1,234	13,134	310	134
4,698	4,881	4,821	4,207	1,843	1,230	672
1,627	1,921	1,571	1,471	1,236	1,120	963
2,028	1,793	1,294	3,148	755	750	85
699	677	850	686	.....	.....	.....
3,007	1,276	1,078	875	1,197	1,362	1,937
$ 57,627	$ 43,072	$ 64,927	$ 45,948	$ 50,753	$ 33,370	$ 28,100
$ 6,865	$ 4,859	$ 4,490	$ 2,810	$ 2,667	$ 2,014	$ 1,887
11,113	9,970	8,242	6,833	6,223	6,592	6,957
7,566	6,879	5,703	4,673	2,635	2,143	1,988
10,076	8,509	6,815	13,096	10,725	5,768	2,384
1,062	1,241	72	261	144	503	608
965	831	1,208	1,463	4,457	1,217	2,058
37,647	32,289	26,530	29,136	26,851	18,237	15,882
19,980	10,783	38,397	16,812	23,902	15,133	12,218
259,882	239,902	229,119	190,722	173,910	150,008	134,875
6,441	6,939	7,064	5,880	4,658	3,411	3,374
$253,441	**$232,963**	**$222,055**	**$184,842**	**$169,252**	**$146,597**	**$131,501**

NOTES TO FINANCIAL STATEMENTS

A — INVESTMENTS

Total market value of investments approximated $395,428,000 and $320,330,000 at June 30, 1971 and 1970. Such amounts include market values of certain real estate which were determined by professional appraisers. See the schedule of investments which appears on page 344 for further details.

B — STUDENT LOAN FUNDS

National Defense Student Loan Funds of $4,967,000 and $4,093,000 at June 30, 1971 and 1970 respectively are ultimately refundable to the United States Government as the loans are repaid.

C — MORTGAGE BONDS AND NOTES PAYABLE

Mortgage Bonds and Notes payable consist of the following at June 30, 1971 and 1970:

	1971	1970
M.I.T. Construction and Consolidation Bonds of 1968:		
Series A, 3½%, due 1971–2003	$ 5,378,000	$ 5,473,000
Series B, 3¾%, due 1971–2015	3,886,000	3,940,000
Series C, 3%, due 1971–2018	1,670,000	1,670,000
	$10,934,000	$11,083,000
Dining facilities bonds, 3⅛%, due 1971–1999	342,000	349,000
Mortgage notes payable, 5¼%, due 1971–1978	747,000	826,000
Mortgage notes payable, 5¼%, due 1971–1981	153,000	828,000
Residential facility lease purchase obligation (note D)	1,385,000	.....
	$14,161,000	**$13,086,000**

D — COMMITMENTS

On November 12, 1970, the Massachusetts Health and Education Facilities Authority agreed to construct a Residence Facility and provide additions to Heating and Chilled Water Plant for lease to the Institute with title passing to the Institute upon expiration of the leases. Construction costs of $10,500,000 are being met by an issue of Authority Bonds. The Institute will pay additional costs required to complete the Residence Facility.

Construction costs of the Residence Facility incurred to date, recorded as educational plant, amount to $1,738,000 of which $1,385,000 represents the associated liability to the Authority. Annual payments under the thirty-year lease purchase agreement approximate $350,000.

Annual rentals for the Utility Facilities, which are being leased for their estimated 25 year useful lives, approximate $400,000 and will be charged to plant operations as incurred.

E — RETIREMENT FUNDS

The Institute's retirement plans, which cover substantially all employees, are under the supervision of trustees. Plan assets are not included in the Institute's financial statements. Current service costs of the plans are funded as incurred; prior service costs are expected to be fully funded in approximately fifteen years. Pension expense charged to operations was $7,293,000 and $7,234,000 in fiscal 1971 and 1970, respectively. Improvements in retirement and other benefits increased costs of the Retirement Plan for Employees by $450,000 annually and its unfunded prior service liability by $2,600,000. A change in the actuarial method and assumptions used in computing pension costs of the Retirement Plan for Staff Members reduced required Institute contributions by $600,000 annually. Changes effective for these plans on July 1, 1971 will increase cost in subsequent years.

AUDITOR'S CERTIFICATE

TO THE AUDITING COMMITTEE OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY:

We have examined the following financial statements of Massachusetts Institute of Technology:

Schedule A — Sources of Revenues and Funds Used to Meet Expenses of Current Operations for the Years Ended June 30, 1971 and 1970.

Schedule B — Balance Sheets as of June 30, 1971 and 1970.

Schedule C — Statement of Funds for the Year Ended June 30, 1971.

Schedule D — Summary of Changes in Funds for the Ten years Ended June 30, 1971.

Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances. We previously performed similar examinations of the financial statements for each of the nine years ended June 30, 1970.

In our opinion, said statements present fairly the financial position of Massachusetts Institute of Technology at June 30, 1971 and 1970, and the results of its operations for the years then ended and changes in funds for the ten years ended June 30, 1971, in conformity with generally accepted accounting principles applied on a consistent basis.

LYBRAND, ROSS BROS. & MONTGOMERY

Boston, Massachusetts, September 17, 1971

REPORT OF THE AUDITING COMMITTEE

TO THE CORPORATION OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY:

The Auditing Committee reports that Lybrand, Ross Bros. & Montgomery were engaged to make an audit of the books and accounts of the Institute for the fiscal year ended June 30, 1971, and their certificate is submitted herewith.

Respectfully,
DONALD F. CARPENTER
DAVID A. SHEPARD
FRANK R. MILLIKEN, *Chairman*

VICE PRESIDENT, OPERATIONS

As with other segments of the Institute, operations activities this past year witnessed a decreasing emphasis on demands occasioned by group protest situations and, with the growing financial burdens on the Institute, much attention was devoted to problems of cost control, cost reduction, and organizational efficiencies. As may be seen in the following sections of this report, all departments shared in these efforts and are pledged to continue them. During the year, the pace of construction activities slackened measurably and preparations were made for several major organizational changes occasioned by the retirement of long-time key administrative section heads.

At the end of the year, Frank H. Conant, Director of the Graphic Arts Service, retired after 44 years of service, and Carl M. F. Peterson, Director of Physical Plant, retired after 42 years of service. These two able and dedicated administrators witnessed great changes in the Institute and effectively adjusted and lead their respective organizations to meet these changes.

PHYSICAL PLANT

OPERATIONS

The effect of curtailed operating budgets has been tempered in considerable measure by improved scheduling and control of the work and an important reduction in the incidence of overtime expense. Cost control effectiveness was furthered by some organizational restructuring and continued changes in operating procedures. Intensive efforts have

been made this past year in gradually evolving and implementing a job-cost oriented work order control system. Much work remains to be done, but initial results are promising and the acceptance on the part of our operating personnel of the modified procedures necessary to implement this system has been encouraging.

A most significant area for concern in plant operations has been the impact in the Institute's cost of purchased energy and utilities. For reasons well-publicized in the news media, coupled with legislation governing emission standards, the price of heavy fuel oil has risen sharply. The fact that the cost of gas and electricity are tied to the price of heavy fuel oil has further compounded this severe cost problem. We are continuing to examine all potential avenues for minimizing our consumption of energy and utilities to help reduce the impact of their rising costs.

CONSTRUCTION

Unsettled conditions in the construction industry continued to affect the pace of construction work at M.I.T. MacGregor House was placed in operation last September in spite of summer and fall strikes in key construction trades. The building was dedicated in November, 1970.

Because of spiraling cost escalation, it was necessary to make adjustments in scope and design to meet budget targets in two major new projects, the Westgate II Graduate Student Apartments and the Electrical Engineering and Communications Research Facility. Construction on Westgate II began in November, 1970, and on the Electrical Engineering Building in April, 1971.

Two new projects which started during the year were the George R. Wallace, Jr. Astrophysical Observatory and the J. B. Carr Indoor Tennis Courts. The observatory, located in Westford, Massachusetts, houses 16″ and 24″ telescopes and was completed in May, 1971. The indoor tennis facility, scheduled for completion in September, 1971, will be located north of the Burton-Conner dormitory. An air inflated shelter will be installed over four existing courts with interior lighting and heating facilities.

Construction continued during the year on the Burton-Conner dormitory renovation and the Central Utilities Expansion. A completely redesigned and renewed Burton-Conner is scheduled to be ready for returning students in September. The new 100,000 pound per hour steam boiler is expected to be on line for the fall heating season, providing adequate reserve steam capacity and expansion capability. Additional chilled water capacity for central air conditioning to new construction projects is expected to be operational next summer.

The chilled water expansion, the boiler, and Westgate II were financed through bonds issued by the Massachusetts Health and Educational Facilities Authority. The tax exempt bond issue, the Institute's first, was also the first college bond series issued by the Authority.

The Westgate portion of the bonds will be subsidized by a debt service grant from the Federal Government's college housing loan program.

Two major alteration projects were completed during the year and two more initiated. The Sancta Maria Hospital on Memorial Drive was renovated for use by the Medical Department as an infirmary, and a portion of a building on Carleton Street was renovated for use by the M.I.T. Press.

Two major renovation projects are going forward in Building 6, the upgrading of floors 1, 3, and 4, and the layout of a Center for Theoretical Chemistry on the second floor. These are a continuing part of the overall Department of Chemistry space improvement which began with the new Dreyfus Building.

In addition to advancing equal employment opportunity for M.I.T. employees, efforts also have been made to increase the role of both minority workers and contractors in Institute construction. The ratios of minority group workers on campus construction projects have more than tripled in the past 12 months, and over a dozen new minority contractors and subcontractors have been performing work at M.I.T.

HOUSING AND DINING SERVICES

This fall much attention was devoted to opening the Frank S. MacGregor House for 324 undergraduate students. In suite-style accommodations, each resident is provided with his own study-bedroom. The house has been well-received and represents the first embodiment of residential life style on the campus envisioned in the 1963 Interim Report on Undergraduate Housing.

Renovation work continued on the Burton-Conner House. When completed in September, 1971, it will house 344 undergraduate students in modified apartment-style accommodations somewhat similar to MacGregor House.

Occupancy is planned in September, 1972, for Westgate II, a high-rise complex designed to house approximately 400 graduate students in one- to four-bedroom apartments.

Inflationary costs and changing student desires in life styles combine to challenge the management of the Housing and Dining Services.

Modifications in services and operations are continually being studied. Flexibility and an ability to adjust to these changing conditions are important ingredients at this time.

In response to student input, the Dining Service, working in conjunction with the Office of the Dean for Student Affairs, student representatives, and other Institute administrators, has agreed upon a campus-wide program of optional food contracts on an experimental basis for one year commencing this fall. This plan represents a significant departure from existing policy where each resident of an undergraduate dormitory having a dining facility is obliged to contract for a meal plan. The outcome of the experiment will have a significant effect on the future direction of our campus food service program.

CAMPUS PATROL

Close communication with the various elements of the Institute community continues as the cornerstone of the Campus Patrol's operation, as evidenced by the continually increasing numbers of requests for help and service which are received over the 24 hours of the day. Such calls, coupled with routine patrol coverage about the Institute and the many demands involved in enforcement of traffic and parking, constitute a full and demanding load on the group. In addition, however, we are witnessing a marked increase in vandalism, car and bicycle thefts, as well as more serious offenses. As a result of these increased burdens, the authorized complement of patrolmen has been increased to a total of 42. The recruiting and training of additional personnel, however, is difficult. Individuals possessing the skills, patience, and understanding necessary for duty on a university campus today are not easy to find. In spite of this difficulty, Campus Patrol continues to attract and retain a group of highly competent and uniquely qualified people.

SAFETY OFFICE

The accident frequency rate moved upward during the past year; the severity rate closely following it. The Institute has been free of the more serious fire losses that have been experienced by some of our sister institutions, with automatic sprinkler protection extinguishing 12 fires as compared with nine in the previous year. The installation of this type of automatic protection continues under a long-term program.

For the first time in many years, fire extinguishing equipment has

been tampered with maliciously. Increased inspection and surveillance have been instituted.

Recent legislation under the Occupational Safety and Health Standards Act has given broad powers to the Department of Labor for safety standards, making mandatory many of the recommended standards of the past. A program of information and education is being carried on, particularly with supervisors, to acquaint them with the new provisions and to have them review applicable safety standards.

GRAPHIC ARTS SERVICE

The decrease in available budgets throughout the Institute has resulted in a 7 per cent decline in this service's gross dollar volume. In contrast to this fact, the total number of job requests and copies of material produced have increased. This reflects a trend on the part of many users to sacrifice better quality printing for a duplicating process of lesser quality at a lower cost. As a result, main offset printing facilities have operated at a lower percentage of capacity, while fast copy centers have increased their productivity.

During the year, the "Letter Shop" and bulk mail services were consolidated into a single service operation to improve efficiency. The desired results are beginning to become apparent.

AUDIO-VISUAL SERVICE

The Audio-Visual Service completed its first year of operation as an independent department and under a new cost system in which users are charged their full share of service expenses. In this initial period, user income was, as expected, substantially less than expenses, but it is anticipated that the gap should shrink considerably in the coming year.

As part of the effort to expand its service to the M.I.T. community, the department undertook projects such as the design and fabrication of original equipment used in the library information program, a major rehabilitation of audio control systems in Kresge Auditorium, and the videotaping of seminars for the Unitel Corporation, an interuniversity group.

PHILIP A. STODDARD

VICE PRESIDENT

The annual reports of Dr. Albert O. Seeler for the Medical Department and Mr. Warren D. Wells for the Registrar's Office follow. Each of these reports is self-sufficient, but I wish to expand somewhat upon the future role of the Medical Department. I also present a brief description of the new experimental academic calendar which provided for the first time during the year 1970-71 a one-month Independent Activity Period between terms. Finally, since the high costs and shortages of housing in this densely populated urban area seem increasingly to plague all who wish to reside in or near Cambridge, I report an overview of progress in our off-campus housing programs.

MEDICAL DEPARTMENT — PLANNING FOR THE FUTURE

Dr. Seeler's report for this past year is similar to prior annual reports he and his predecessors have presented. Each year, the Medical Department has experienced an increase in utilization of that department's services by students and by faculty, staff, and employees. Each year, the department has found it necessary to respond to the needs of the Institute's population by expanding the range of health services provided, and each year the department has been constrained in some measure by the physical facilities available to it.

While it is gratifying to see this continued evidence that the quality of the services provided by the medical staff is so highly regarded by both students and employees, particularly in light of the usual regard for "typical" university health services, Dr. Seeler, his medical associates, and other related members of the M.I.T. administration and Corporation

have been concerned for some time about the longer range implications of the continued growth in utilization and range of services provided.

Since medical costs continue to rise at an even more rapid rate than the costs of other products and services, the increases in per capita utilization have resulted in more than proportionate increases in budgetary requirements. Financial projections for the future are startling indeed. In addition, the problems of identifying and attracting to our staff adequate numbers of qualified professional and trained support personnel are mounting in severity.

It is unlikely that control of these escalating demands upon resources can be achieved through mechanisms which curtail health care services delivered to students or to faculty, staff, and employees. Although other methods might be utilized to fulfill what has become a university obligation to its students (for example, by contracting for such health care delivery with external professional service organizations), it is clear that the Institute must continue to assume major responsibility for the health of its student body. For full-time staff and employees, the Institute has had a policy, since 1933, of offering free ambulatory health care through the Medical Department. In addition, we have developed progressively more generous health coverage through Blue Cross-Blue Shield benefits, the costs of which are borne largely by the Institute. Thus it does not appear to be realistic to consider as a method to counter rising costs major curtailment of these important staff and employee benefits, although, as is the case for students, other mechanisms to discharge these responsibilities are feasible.

The situation is further aggravated by the general shortage of medical practitioners in those areas where many staff and employees reside. This shortage appears to result in a growing tendency among staff and employees to look to the Medical Department for health care. The department receives each year a growing number of requests for assistance for employees' dependents who are presently not eligible to receive other than emergency care.

At this time that mechanism which shows greatest promise of permitting us to discharge our health-care responsibilities within a framework of controlled costs for both ambulatory and hospital care is the "critical-size" joint-practice health care delivery organization. Since the staff of the Medical Department has considerable experience in what is, in effect, a group practice, and since they have had considerable success in developing mechanisms for more productive and efficient use of professionals, para-professionals, technical assistants, and administrative assistants, this staff seems to provide an invaluable nucleus upon which to build a strong health care delivery system which could assume

responsibility for essentially all health care of students and of those staff members and employees and their dependents who elect to participate.

As Dr. Seeler reports, we anticipate mounting in the near future an experimental effort involving about 1,000 families. The purpose of this experiment will be to gain sufficient first-hand experience to permit intelligent planning for a larger operation. Although it is conceivable that this experiment might lead us to conclude that we must seek ways external to the Institute to discharge our present and future medical responsibilities for members of the Institute community, my firm prediction is quite the opposite. Accordingly, I believe it is important that the senior officers of the Institute be alerted to the increased needs for space and personnel which will be required to provide health care to those members of our community who will look to the Institute for this important service. Although our financial analyses presently indicate that such a "pre-paid, joint-practice, health care delivery system" offers great potential for delivering good health services, at costs to the Institute and to the recipient which are "reasonable" and "controlled," there will be appreciable "start-up" costs required for facilities and operations before a critical-size, financially stable operation is realized.

THE NEW ACADEMIC CALENDAR — THE "INDEPENDENT ACTIVITY PERIOD"

This was the first year of a three-year educational experiment with a new form of academic calendar. The traditional two-term calendar on which the Institute's academic program had been scheduled for several decades was modified to a "four-one-four" plan. The durations of the fall term and the spring term were shortened, each to about four months, and the intervening month of January was devoted to an "Independent Activity Period." The general staff-student assessment of this first effort was so favorable that the "I.A.P." calendar will be continued for the remaining two academic years of the three-year experiment adopted by the Faculty.

This new calendar resulted from a study by the ad-hoc calendar committee appointed by the Provost in May 1968 and chaired by Professor James R. Munkres. This committee was formed in response to an increasing sense of general dissatisfaction with certain aspects of the old two-term calendar. The Munkres calendar committee made specific these objections by establishing as its objectives the following:

1. The elimination of the January "lame-duck period," the short period scheduled for regular classes between Christmas vacation and the January examination period;

2. The easing of the between-terms rush for conducting required academic and administrative processes;
3. The provision of some amount of "fallow time" to be used by students and staff for study and research at a more leisurely and independent pace than is possible during regular terms, and the provision of an opportunity for flexibility in learning and teaching styles. The committee felt that the most critical educational problems for students were "constant pressure" and "lack of time."

Following an assessment of a wide spectrum of possible calendars, the Munkres committee, joined by the Committee on Educational Policy, recommended to the Faculty in March 1970 that a new "4-1-4" calendar be initiated for a three-year trial period. Toward realization of the above objectives, the new calendar, in contrast to the two-term calendar, provided for:
1. Shifting the entire academic year ahead by about one week (but not shortening the total duration time) to run typically from early September to late May rather than from typically mid-September to early June;
2. Reducing the duration of the first and second terms from about fifteen weeks to about fourteen weeks each;
3. Completing the first term examination period before the beginning of Christmas vacation rather than in mid- to late-January;
4. Devoting the month of January to "independent activity" rather than a combination of end-of-first-term classes, examination period, and between-terms vacation;
5. Providing additional two-day class vacation periods (similar to the traditional Thanksgiving holiday weekend) on Columbus Day or Veteran's Day in the first term, and on Washington's Birthday and Patriots' Day in the second term to provide three additional four-day weekends in place of the traditional three-day weekends.

The January Independent Activities Period ("I.A.P.") was considered to be the primary mechanism permitting and encouraging members of the teaching staff and students to find new or alternate ways to study, to perform research or scholarly work, or to enjoy cultural or recreational activities. The "key word" was "independent" in that the objective was to provide new opportunities to formulate and follow plans which matched individual teaching-learning styles.

In March 1970, the Faculty voted to establish the new calendar for a three-year experimental period beginning with the year 1970-71. Given the short intervening time for planning and implementation, two faculty-student-staff task force subcommittees of the C.E.P. were established. One committee, chaired by Professor Robert G. Gallager, was to "advise and assist" departments and other organizations in planning and imple-

menting the I.A.P. The second committee, chaired by Professor Kent F. Hansen, was to evaluate the January 1971 I.A.P. and to recommend continuation or modification for succeeding years. I was asked to oversee the several administrative changes which were required as a result of the adoption of the new calendar.

An additional complication in planning and implementing the new 4-1-4 calendar resulted from the deep disturbances almost all academic institutions faced following the Cambodian invasion and the Kent State National Guard shootings in the late spring. In an effort to encourage heightened student interest in participation in the normal elective processes, the Faculty in late May voted to provide a one-week fall recess during the last week of October 1970. In order not to decrease the number of class days in the new shorter first term, the additional class vacation day at Columbus Day weekend was cancelled, academic exercises were held on two Saturdays, and the beginning of the Christmas vacation was delayed one day.

The Gallager subcommittee established a network of staff "coordinators" in the various departments and, with the cooperation of the Student Committee on Educational Policy, established I.A.P. information centers and other "rapid-response" written and verbal communication networks. This committee assembled information concerning essentially all of the offerings by staff members and student groups and published a 45-page "I.A.P. mini-catalog" in early December 1970. During the course of its work, the committee found over and over again that a given problem reduced to an assessment of a fine balance between the establishment of some "structure" to assure some degree of success and the completely unstructured truly to test the experimental "independent activity" concept.

The Hansen evaluation subcommittee, after considerable effort to formulate only quantitative methods for its evaluation task, ultimately decided upon a dual quantitative-qualitative approach. The committee developed separate questionnaires for students and for the teaching staff, designed to elicit both quantitative information for statistical analysis and qualitative information. The information was sought to establish a measure of the value of this educational experience in terms of the personal satisfaction of the individual participants.

In addition to the reduction and interpretation of the data gathered through the questionnaires, the committee also hosted a number of "post-mortem" discussion sessions with various administrative, faculty, and student groups.

The number of teaching staff and students who responded to the questionnaires was surprisingly high, and the individual evaluations were

generally very favorable. Similarly, the consensus reached in the group discussions was also favorable.

A paraphrasing of the Hansen committee's principal findings follows:
1. Both students and faculty favored the I.A.P.;
2. Both students and faculty were on campus during the I.A.P. in sizeable majorities;
3. There was virtually unanimous opinion among faculty and students that the ending of the fall term before Christmas is an excellent idea;
4. Most students were very appreciative of the opportunity to be at M.I.T. in the absence of the usual acadamic-schedule pressures;
5. Both students and faculty were unhappy with the shortened fall term;
6. There were no major problems of an academic or administrative nature created by the I.A.P.

The committee, therefore, concluded that the original objectives set forth by the Munkres committee and the C.E.P. had largely been realized, although the late introduction of the one-week October vacation and curtailment of the originally planned four-day weekends had had a negative impact. A separate C.E.P.-sponsored evaluation of the fall term also indicated similar dissatisfaction so that the Faculty voted in March 1971 to abandon the October recess. With this change and in view of the generally favorable endorsement found by the Hansen committee, the remaining two of the three-year experiment with the 4-1-4 I.A.P. calendar will be continued.

A new combined planning-administrating-evaluating group chaired again by Professor Hansen will be responsible for the I.A.P. next year. Given the 1970-71 experience with the new calendar, there is every evidence that some of the deficiencies associated with a shorter first term and late planning will be rectified.

A large number of administrative adjustments were required to conform to the new calendar. The more significant of these follow:
1. A change was made in the time duration of academic year appointments, from September 16 – June 15 to September 1 – May 31. Clarification of the modified annual salary plan was also made;
2. Special graduate "scholarship" arrangements were made to compensate for the "2½ month" summer of 1970;
3. Modifications of tuition, room and board, and medical fees were made to permit I.A.P. flexibility;
4. Modifications in freshman orientation schedules, athletic schedules, and alumni program schedules were adopted;
5. Special information dissemination techniques were developed to encourage flexibility and individual initiative.

Given the complexity of the institution, the relative "open-endedness"

of the I.A.P. concept, and the "last minute" character of several of the changes made by the Faculty, the transition to and the programs developed for this new calendar were remarkably successful. Considerable credit for these accomplishments is due many students, faculty, and staff members. In particular, Professor Munkres was a consistent and resourceful guiding light since 1968. For the entire first term of 1970 and the I.A.P. period, Professor Gallager devoted an extraordinary amount of concentrated effort and exhibited great skill in the day-to-day interpretation and implementation of the broad I.A.P. guide-lines established by the Faculty. Finally, Professor Hansen has gone far beyond the call of duty, both to lead the development of an evaluation of a very complex experiment and to accept the leading responsibility for the further refinement and development of the new calendar for the coming year.

OFF-CAMPUS HOUSING

Change and progress in the Institute's on-campus housing program has been reported year by year by both the Vice President for Operations and by the Dean for Student Affairs. This year Dean Sorenson reports on the major impact the new MacGregor House and remodeled Burton-Conner have on our undergraduate housing program and the high hopes we have for additional graduate housing to be made available in September 1972 with the opening of Westgate II now under construction. He also reports on the problems which continue to plague our efforts to undertake significant new fraternity house construction. Fraternities and the M.I.T. Student House are regarded as "on-campus" although they are all located in their own properties not owned by the Institute.

Although our off-campus housing programs have grown significantly over the past few years, they have traditionally not been emphasized in these reports. Thus I feel it is timely to report briefly on several important and exciting developments in these categories of the Institute's overall housing efforts.

INSTITUTE REAL ESTATE OFFICE — NORTHGATE COMMUNITY CORPORATION

A large part of our student body, particularly graduate students, and almost all staff and employees have always found housing "off-campus." Until about the middle of the last decade, the supply of satisfactory housing, the commercially-available real estate and rental agencies, and a modest Institute-sponsored listing agency seemed to serve adequately the housing needs. By that time a shift in the supply-demand situation for housing, particularly for those lower rental level accommodations reasonably close to the campus so much desired by graduate students

and younger staff and employees, had begun to force rent escalation and a decline in availability of satisfactory listings. Our off-campus listing-referral agency, which had been staffed largely by volunteers working within the office of the then dean of residence and which had provided adequate and sometimes admirable service in the earlier less demanding market situation, was simply no longer able to cope with the problem.

In 1965, in an effort to provide better service to students, employees, and staff seeking off-campus housing, both rental and purchased, and in an effort to add to available housing resources, the Institute Real Estate Office was created as a part of the Treasurer's Office and the Northgate Community Corporation was formed.

Over the past six years the Community Housing Service of the Institute Real Estate Office has developed into an unusual amalgam of a non-profit residential listing-referral agency, a residential and budget planning counseling service, and a legal advisory group.

The staff now consists of four full-time and two full-time summer employees, aided by six volunteers. The number of inquiries of all categories has risen by almost 100 per cent in the period 1966–67 to 1970–71. Over the same period, the staff reports about a 200 per cent increase in demand for residences, and a 55 per cent increase in the rent levels for similar dwelling units. Thus each year the staff must expend greater efforts in preparing newcomers to the Cambridge area to cope with this difficult situation, particularly those who come from the South, Midwest, and the West where rental scales are typically far lower and availability of suitable accommodations typically far greater, and in working with individuals to assist them in coping with a wide spectrum of problems from social to financial.

Although we have made significant progress in counseling newcomers, particularly graduate students, to the local housing problems through information disseminated through academic departments and the offices of the Dean of the Graduate School, the Dean for Student Affairs, and the Foreign Student Advisor and by direct communications sent from the Community Housing Service, there is ample evidence that many incoming students and staff are both essentially unprepared and extremely frustrated in coping with the residential problems they find.

While the Community Housing Service was established to provide better "brokerage" service, the Northgate Community Corporation was established to add to the available "housing stock." This Corporation is a section 180 corporation under Massachusetts law which, for all intents and purposes is not operated for profit. The Corporation has the objectives of creating some "controlled" inventory of off-campus housing for M.I.T. personnel and students, providing some "leveling"

influence on area rental levels by efficient, non-profit, "below market" operation, and adding to the total local housing stock through new construction. While it is an affiliate of the Institute, the Corporation, and therefore its tenants, does not receive operating subsidies from the Institute, and full real estate taxes are paid to those municipalities in which Northgate dwelling units are located.

Excluding the capacity of Random Hall, which will be reclaimed this summer by Northgate from use as a "temporary" Institute House for about 100 men, Northgate has presently about 470 dwelling units, all in multi-unit structures. Some of these are in buildings on which the Corporation holds long-term leases; others are in buildings owned by the Corporation. Of this total some 319 units are in several Cambridge and Somerville locations, the remaining are located in outlying communities such as Arlington and Medford.

Not all tenants in Northgate properties are affiliated with M.I.T. As a matter of policy, Northgate has not evicted "indigenous" tenants who occupied units in buildings at the time Northgate acquired control. In addition, Northgate has from time to time provided housing for people in the greater community facing undue hardships; 39 Cambridge units, for example, are rented to the Cambridge Housing Authority for use as low income rental units under the leased housing program. This mixed tenancy situation has created unusual problems for Northgate with respect to the application of rent control statutes adopted by Cambridge and Somerville in January of this year. As of this writing, a resolution of the matter has not been achieved.

In recognition of the particularly severe Cambridge housing problems, about two years ago Northgate adopted a policy of not acquiring any additional residential properties in Cambridge except for a few rare instances in which the acquisition of a small residential property adjacent to a large tract already owned would make possible the construction of a significant number of new residential units. As a consequence, all of the more recent Northgate purchases or blanket lease arrangements have been made outside of Cambridge. For the acquisition of additional dwelling units within Cambridge, the Corporation is now concentrating on new construction. A first step in such construction is the "1000 Massachusetts Avenue" project under the "Five Site Program."

A HOUSING PROGRAM FOR CAMBRIDGE — THE "FIVE SITE PROGRAM"

In what we believe to be a unique effort on the part of a private educational institution to respond to the pressing housing needs of its neighbors in an urban setting, M.I.T. announced a housing program for Cam-

bridge in April 1969. In addition to announcing plans for new accommodations for about 800 students on campus, the Institute proposed to initiate and/or assist in the construction of about 1,600 new dwelling units on five off-campus, underdeveloped, and partially blighted sites in various parts of Cambridge. Of the total of 1,600 units, about 750 were proposed as being made available to low-income families and elderly persons under governmental subsidies; the remainder were proposed to serve other Cambridge residents and M.I.T. personnel at the lowest feasible market rental levels.

At the time of announcement, the tentative plans called for the development of approximately 200 low income family/elderly dwelling units and supporting facilities at each of three sites, on Erie Street in Cambridgeport, Gore Street in East Cambridge, and Clarendon Avenue in North Cambridge. A commercially-financed development by the Northgate Community Corporation for about 250 to 300 dwelling units and some commercial facilities was envisioned for a site at 1000 Massachusetts Avenue between Central and Harvard Squares. Finally, a mixed development of subsidized and commercially-financed dwellings totaling about 800 units was proposed for a Portland Street site in East Cambridge.

Although the Federal Turnkey Program had not yet received legal sanction in Massachusetts at the time this massive effort was announced, financing and ultimate ownership of the proposed low-income family and elderly units were planned under the Federal "turnkey" program. The Institute, through its Real Estate Office, was to be a no gain — no loss developer of the projects, which, upon completion, would be "sold" to and operated by the Cambridge Housing Authority, financed in turn through Federal funding.

Beginning in the spring of 1969, staff members of the Institute Real Estate Office assisted by staff members of the Planning Office, Chairman's Office, and others undertook a massive effort in developing relationships with local community organizations and groups and with Cambridge governmental agencies. The objective was to develop programs for the Clarendon Avenue, Gore Street, and Erie Street sites which met the needs and wishes of the many constituencies. During the course of a large number of meetings and discussions, modifications in the initially proposed programs were developed, and general local and community support for the Institute's effort evolved. In addition, although the 1000 Massachusetts Avenue site was not planned as a subsidized program, community support for this development was also achieved.

Thus in December 1969, a major step forward was accomplished

toward the development of these four sites for residential purposes when the Cambridge Planning Board and the Cambridge City Council approved changes in zoning on all four sites to permit the required densities of residential construction for which the program called.

Continued staff-community efforts resulted in gradual refinement of the programs for the subsidized projects. In March 1970, Benjamin Thompson and Associates, Incorporated of Cambridge was retained as architect for the Clarendon Avenue, Gore Street, and Erie Street sites. The program by this time had evolved into the development of housing for the elderly on these three sites plus the development of 16 low-income family units at the Erie Street site.

In late 1970, the Cambridge Housing Authority advertised for bids for both elderly and family turnkey projects; legal obstacles in Massachusetts to the turnkey program by this time had been removed. Several bidders responded, but the Authority recommended in April 1971 and the Department of Housing and Urban Development approved in May 1971 the Institute's proposal for elderly housing. The sixteen-unit family housing portion, however, was not accepted.

Thus the Institute is presently the developer of the largest turnkey program to date, 684 units of housing for the elderly, 199 at the Clarendon Avenue site, 304 at the Gore Street site, and 161 at the Erie Street site. At this writing negotiations with contractors are moving toward completion so that, hopefully, groundbreaking will take place before the winter of 1971-72. Cooperative planning with local community groups continues. Their concerns are now shifted to such matters as the program development for the recreational areas and clinic, management, and tenant selection.

Although there remain many hurdles to be surmounted before these projects are finally ready for their occupants, we are confident that the team which carried through so successfully to date will see the program to a successful conclusion. The Institute, and Cambridge, owe special thanks and recognition to Mr. Antony Herrey, Director of the Institute Real Estate Office; Mr. Walter L. Milne, Assistant to the Chairman of the Corporation; and Mr. O. Robert Simha, Planning Officer in the Institute Planning Office.

For the Northgate-sponsored 1000 Massachusetts Avenue site, Imre and Anthony Halasz, Inc., were chosen as architects in June 1970. Preliminary plans developed by this firm for an exciting residential-commercial complex have been reviewed by the Northgate Community Corporation. At the present time, refinements, and cost reducing modifications are in progress. However, a target date has not yet been established for completion of the project.

Although "low-key" community involvement efforts relating to the Portland Street development were undertaken concurrently with the intensive efforts for the three subsidized housing projects, no significant progress had been made by early 1971 in achieving consensus on the density of the development, and apportionment between subsidized and non-subsidized units. Consequently, these efforts were redoubled during this past spring. Suffice it to say, however, that it became very apparent to our staff that the various local community groups and city agencies involved did not and would not support a development at a density approaching that which we had earlier conceived as being financially feasible. This lack of consensus, taken in the context of our having succeeded in mounting a program for a number of subsidized housing units close to the original target of 750, and of our now having new opportunities for housing development through the acquisition of the Simplex properties led us to conclude that we should abandon, at least for the near term, our attempts to use the Portland Street site to achieve a portion of our overall Cambridge housing program. The owners of the site, with whom we had a working agreement, graciously and cooperatively accepted the expiration of the agreement on June 30.

SIMPLEX — THE NORTHWEST AREA

The generally run-down, outmoded industrial belt of some 135 gross acres which lies north and west of Briggs field and Massachusetts Avenue has long isolated the campus playing fields and student residences from residential Cambridgeport. In this area, described as "the Northwest Area," the Institute has for some time owned several relatively small parcels of land, but there had been no specific plans made with respect to the long-term utilization of these properties.

In 1969, M.I.T. was faced with what was at once a set of serious problems and a unique set of opportunities when the Simplex Wire and Cable Company placed on the market its real estate holdings in this Northwest Area. The company's facilities occupied 11 sites with a total land area of about 19 acres. While Simplex had been a productive employer of over 1,000 persons some time ago, the company's production facilities had become outmoded and uneconomical, resulting in financial losses and declines in sales and employment. Thus the company felt it had no choice but to move to new modern facilities in South Berwick, Maine.

The problems this offering posed for M.I.T. were evident. The price of the property was high (at the time of final transfer of ownership in March 1970, the selling price of $12,750,000 was made public); the

majority of the buildings on the land were so old and outmoded as to be essentially liabilities; although the long-term potential for reasonable investment return was good (the property was purchased as a part of the Institute's investment portfolio), the shorter-term prospects were marginal; there was the possibility that another new owner might use the industrial land in such a way as to continue over the long term the existing "environmental blight" or use the land in other ways not sympathetic to the needs both of the campus and of Cambridgeport; and, finally, there were all of the political problems associated with the general outcry of "university land-grabbing" in Cambridge.

The opportunities, however, were most attractive. The large Simplex land area in combination with the other M.I.T. properties nearby could form a holding approaching the critical size required for massive redevelopment; the land offered great promise for renewed and economically viable commercial, job-producing, tax-paying development, for much needed residential development, and for significant and important environmental improvements — for the benefit of Cambridge and of the Institute.

The decision to go ahead with the purchase was made in the summer of 1969. At the time of the announcement of the purchase, July 1969, the Institute made public several policy guidelines which we proposed to follow in redeveloping the Simplex properties. Important among these were:

1. To seek ways in which new commercial activity would add to the employment opportunities and tax base of the city;
2. To seek to add relief for the ever-mounting pressure on the city's limited housing stock by developing more taxable housing for the M.I.T. community on the Simplex land;
3. Not to use portions of the site for further expansion of non-taxable academic and research plant.

Our planning efforts since that time have been guided by these broad guidelines, but we have also benefited greatly from advice and counsel from several sources. A short time after the announcement of our Simplex purchase, President Johnson appointed a faculty advisory group to work with members of the staffs of the Planning Office and Treasurer's Office and with me, to develop broad planning criteria on which specific implementation plans might be drawn. Professor John T. Howard, then head of the Department of Urban Planning; Professor Donlyn Lyndon, head of the Department of Architecture; Professor Robert W. Mann of the Department of Mechanical Engineering; and Professor Kenneth F. Reinschmidt of the Department of Civil Engineering provided invaluable assistance during the academic year 1969-70.

Their efforts formed the basis for later considerations of a more broadly representative committee, the Corporation Joint Advisory Committee.

This Committee, under the chairmanship of Gregory Smith, spent many hours on the "Simplex problem" and reported its findings to the M.I.T. Corporation over the summer of 1970. Both the Corporation Joint Advisory Committee and the Faculty Advisory Group strongly endorsed the general policy objectives which had been announced at the time of purchase of the Simplex property. There was also a strong consensus reached on many planning criteria, but the members of C.J.A.C. were divided on some specifics concerning the desirable "mix" of commercial and residential construction and the desirable "mix" of type of residential units to be developed. This very division in point of view among the committee members proved to be valuable to the administrative staff concerned because the many discussions provided considerable clarification and "sharpening" of the many planning problems.

Following upon and based upon C.J.A.C.'s report to the Corporation, a Pilot Planning Program was undertaken which, at this writing, is in the concluding phases. Mr. Richard P. Dober, the Institute's long range planning officer, has been project director and several staff members have served as a steering committee to this action-oriented task force effort for the planning and development of the Simplex and related properties. The objectives have been:

1. To develop in greater specificity, than that presently available, the program dimensions of residential and commercial activities to be accommodated in the land;
2. To help establish cost and benefit estimates and financing mechanisms for executing projects;
3. To identify the organizational structures and the time scale for developing the land;
4. To provide essential information on the options available in using the land so as to constructively respond to developer and community interest, particularly those questions of financial feasibility, environmental design, tax contributions, job opportunities, zoning, and infrastructure changes in the area.

We had earlier looked to a commercial/industrial program as a first-phase of redevelopment to "trigger" other new development and also to offset in part the high land costs for adjacent residential developments. However, over the two-year period during which we have undertaken successive stages of planning, the downturn in the general economy has resulted in a very soft market for commercial/industrial space in the greater-Boston market. At the present time, therefore, we believe that,

if we are to undertake redevelopment in the near term, the initial phases should be of residences and of supporting facilities for a residential area.

Given the presently blighted and unattractive nature of the surrounding area, the residential development, to be attractive and viable, must necessarily be of relatively large scale, probably of the order of 15 acres and 1,000 or more dwelling units. We are presently exploring in detail such matters as the desirable number of distribution of types of dwelling units, mixes of row-houses, low-rise and high-rise structures, community facilities, the associated financing plans and implementation devices.

Given the relatively high cost of the land, the average density of such a development will probably be about 80 units per acre. Thus the quality of the final site planning and development and of architectural design will be critical to the success of the development.

Fortunately, we have been able to formulate a number of site utilization schemes which provide great flexibility for later development phases, commercial and/or residential, as need and market conditions dictate.

In addition to finding solutions to the financial problems posed by high land values and high construction costs, we must also face all of the problems attendant to achieving street and utility realignment, zoning change and community acceptance and support, development of adequate community support facilities, marketing acceptability to members of the M.I.T. community and others, and identification of most promising and efficient development mechanisms.

We look to presenting to senior administrative and corporation officers a specific plan of attack for residential development early in the fall term 1971. Although our apparent progress has been less rapid than might be desired, I am conscious of Mr. Dober's observation to the effect that "even fast track action plans in real estate development take place on a time scale which sometimes appears to be glacial."

KENNETH R. WADLEIGH

MEDICAL DEPARTMENT

The increase in utilization of the Medical Department continues to be dramatic. The total number of visits to the clinics rose from 61,853 to 71,613, an increase of about 15.8 per cent. The total number of visits to the Medical Department, including the Lincoln Laboratory medical unit and emergency visits to the Infirmary, rose from 77,781

to 84,869, an increase of 9.2 per cent. Lincoln Laboratory visits diminished by 5 per cent and the number of emergency visits to the Infirmary was down 1 per cent. There was an increase of 33.9 per cent in the number of employee visits and 12.4 per cent in the number of staff visits, even though the number of staff and employees at the Institute was about 3 per cent below last year. The number of student visits increased 8.5 per cent. This year for the first time, the number of non-student clinic visits exceeded the number of student clinic visits, the figures being 36,313 non-students and 35,300 students.

Fortunately, the remodeling of the third floor of the Homberg Memorial Building was completed in October, 1970, providing additional medical office space just in time to cope with the increased demand for medical care. In certain areas, however, our space situation is still unsatisfactory. We do not have adequate space for our nurse practitioners, so they have to share consulting rooms with resulting lack of privacy for their patients. The Medical Record Room is badly cramped. Semi-automatic Diebold files were installed several years ago to save space. This solution to the space problem was satisfactory for a while, but the demand for records is now so great that the slowness of Diebold files creates serious delays. Our Consultant Medical Records Librarian reports that the only solution to the record retrieval problem is open shelf filing, which will require at least twice the space we now have available. Unfortunately, unless an automatic conveyor system is installed, the record files must be either in, or immediately adjacent to, the Department, because records must be delivered promptly to the physician's office.

The old Sancta Maria Hospital was renovated last summer and in September, 1970, became the M.I.T. Infirmary. The additional space has been most welcome, but as predicted, the separation of the ambulatory and inpatient facilities has significantly increased the cost of our operation. As an example, we now need a car and driver to move sick patients from the Clinic to the Infirmary and to shuttle technicians, records, and supplies.

As mentioned in last year's report, the national crisis in health service delivery is reflected in an increasing number of requests for medical care for dependents of M.I.T. faculty, staff, and employees. With the approval of the Medical Department Visiting Committee and the Administration, a study is in progress to determine whether it is feasible for the M.I.T. Medical Department to extend its services to dependents. We have been fortunate in obtaining the assistance of Mr. Daniel F. Creasey of the Analytical Studies Group in guiding this study. Last summer, Mr. Creasey undertook a survey of 1,200

employees, staff and faculty chosen to be a representative sample of the M.I.T. Community. About 70 per cent returned the questionnaire and about 45 per cent stated that they would join a prepaid health program based on the M.I.T. Medical Department, and another 40 per cent reported interest in such a plan, but wanted to know the details before committing themselves. In December, 1970, a contract was arranged with the Harvard Center for Community Health and Medical Care for consulting services, and we expect a report from them on July 1, 1971. Provision of total medical care is a very complex problem, and the professional staff of the Medical Department has been heavily involved in the feasibility study. At the time this report is written, the professional staff believes that it is feasible for the Medical Department to undertake the care of dependents on a prepaid basis, and that about 1,000 families could be enrolled in the near future and cared for with our present facilities. Such a relatively modest venture would involve little financial risk and would give utilization information concerning our particular population that would be invaluable in planning a larger operation.

Dr. Harriet L. Hardy, Assistant Medical Director in Charge of the Environmental Medical Service, has been granted a leave of absence for the coming year and will retire on July 1, 1972. Dr. Hardy plans to teach at Dartmouth Medical School. She came to M.I.T. in 1949 and created the Environmental Medical Service to meet the need to protect the M.I.T. Community from the hazards of radiation and toxic materials. In addition to directing the Environmental Medical Service, she has participated extensively on national committees concerned with the environment, continued to lecture on environmental medicine at Boston medical schools, and has made important contributions to our knowledge of beryllium disease and lead poisoning. She is one of the most distinguished women in American medicine, and M.I.T. has been fortunate to have had her support for so many years.

The sudden death of Dr. John E. Gary, Chief of the Radiology Service, was a great loss. His associate, Dr. Stefan C. Schatzki, has assumed the responsibility for radiology.

During the year, Mrs. Pauline R. Jones, R. N., was appointed Supervisor of our Ambulatory Clinic, and Miss Elinor J. Spita, R.N., was appointed Supervisor of the M.I.T. Infirmary. Dr. Julius E. Goldblatt was promoted to Associate Surgeon in Chief, and Mrs. Jacqueline A. Buck, M.S.S., was promoted to Chief Social Worker. We have been fortunate to have Dr. Edward S. Rendall, an internist, Dr. George Christman, a dentist, and Mrs. Myra A. Rodrigues, M.S.S., a social worker, join our full-time staff.

Appointments during the year were the following: Thomas J. Cottle, Ph.D., Research Sociologist; Arnold W. Fieber, Medical Records Consultant; Chester M. Pierce, M.D., Psychiatrist; Philip J. Porter, M.D., Pediatrician; Robert Poss, M.D., Associate Orthopedic Surgeon; Gustav Schonfeld, M.D., Assistant Physician; John T. Truman, M.D., Pediatrician; and Paul F. Vinger, M.D., Associate Ophthalmologist.

Resignations during the year included: R. Clement Darling, M.D., Surgeon; Robert B. Keller, M.D., Assistant Orthopedic Surgeon; Isaac O. Mehrez, M.D., Surgeon; Gloria A. Rudisch, M.D., Assistant Physician; Jack Sizer, M.D., Assistant Surgeon.

CLINICS

The number of Clinic visits and the distribution among the various categories of the M.I.T. Community are shown in Table I.

The number of general Medical Clinic visits rose from 25,655 visits to 29,274, an increase of 14 per cent. Fortunately, we did not have a major epidemic during the year.

Utilization of the general Surgical Clinic was 4 per cent greater than last year. The visits to the Gynecology and the Orthopedic Clinics increased 27 per cent and 17 per cent respectively, while there was a 3 per cent drop in visits to the Ear, Nose, and Throat Clinic. Comparative figures for urology are not significant because the Urology Clinic began in the middle of the previous year. However, the need for urological consultation is demonstrated by the fact that there were 522 visits to this Clinic during the year.

A total of 327 operations were done in the Infirmary during the eight months that the Infirmary operating room was available. From June through October, when the Infirmary was being renovated, even minor surgical procedures had to be done at the Mount Auburn Hospital or Cambridge Hospital. As usual, the most common among the surgical procedures were the suture of lacerations and the excision of benign skin lesions. Thirteen of the skin lesions excised proved to be malignant.

There were 420 athletic injuries treated during the year, an increase of 14 per cent over last year. The numbers of injuries among the various sports are as follows: football 75; basketball 71; hockey 69; soccer 32; baseball 20; softball 17; rugby 17; skating 15; wrestling 13, and skiing 11.

DENTAL CLINIC

The newly organized Dental Service has just completed its first year. Two categories of patients have been seen. First, students and wives received complete dental care. Secondly, anyone associated with M.I.T.

could obtain dental emergency advice or treatment. A fee, generally 20 per cent to 40 per cent below that charged by private dentists in the Boston area, is charged for each visit. Four completely equipped dental rooms were staffed by one full-time dentist, 2 hygienists, a receptionist, and 2 assistants. Demand for services has been so great that now a part-time secretary, a second full-time dentist, and a third assistant have been added. Through the increased use of professional auxiliaries, it is hoped to increase efficiency and decrease the cost. This first year has demonstrated the need for full dental care for students at M.I.T.

PEDIATRIC CLINIC

In December, 1970, the M.I.T. Medical Department opened a Pediatric Clinic for children of students. This was a new venture in that it was run primarily by a well-trained nurse practitioner, who was backed up by Dr. Philip Porter and his pediatric staff at the Cambridge Hospital. From a rather modest start, the utilization of this Clinic has grown to the point where we estimate that it will be self-supporting by the end of the calendar year. This Clinic is on a fee for service basis and is not presently covered by any insurance or prepaid plan. Starting in July, the Pediatric Clinic will be open to all members of the M.I.T. Community.

ENTERING STUDENT PROGRAM

We are now starting our second year of a simplified procedure for the medical evaluation of entering students. This consists of a simple statement by the family doctor of the student's general condition and evidence of freedom from active tuberculosis and immunization against smallpox and tetanus. While the likelihood of tuberculosis among native born Americans and Canadians is small, the rate for foreign students, particularly those from the Far East, is still high. Last year this system seemed to work well and we hope to continue it.

HEALTH SURVEYS

Voluntary medical examinations for faculty and senior members of the D.S.R. staff were continued. There were 1,004 such examinations performed, a slight increase over last year.

STAFF AND EMPLOYEE HEALTH PROGRAM

A total of 2,300 examinations were performed, 16 per cent fewer than last year. The number of examinations voluntarily sought by patients for health survey purposes, however, rose almost 24 per cent.

We were able to reduce the number of physician hours devoted to these activities because of the smaller number of pre-employment examinations. In addition, a new method of performing compulsory periodic examinations of employees in hazardous occupations was used. One hundred and six of these surveys were performed using a combination of a questionnaire and several physiological tests administered by student paramedics. Examination of these patients under the usual circumstances would have consumed 53 additional hours of physician time. We anticipate the performance of many health surveys, including pre-employment examinations, in this fashion in the future, further conserving physician time.

Only two applicants for employment were found to have health problems sufficiently grave to disqualify them for the jobs they sought. Twenty-three other applicants had significant medical problems, but were hired nonetheless. Of these, 11 had hypertension, 3 had congenital heart disease, 2 had pulmonary fibrosis and one each of the following: horseshoe kidney, Crohn's disease, absence of limb, seizure disorder, bronchiectasis, coronary heart disease, and sarcoid.

There were 29 deaths in the M.I.T. Community during the year. As usual, heart disease was the most common cause of death (18). There were 4 deaths from cancer, 3 from chronic lung disease and 2 from accidents.

PSYCHIATRIC SERVICE

In an effort to improve its accessibility, the Psychiatric Service initiated a program whereby a staff member was always available for brief interviews to help the patient clarify the nature of his problems and arrange for appropriate assistance. This program, which in some respects is a triage operation, has been very successful, and it is now possible for almost all patients to be seen at least briefly on the day they ask for help.

Facilities have been made available for the members of the M.I.T. Community to perform a qualitative analysis of various psychodelic drugs. Data from this project suggest that there is rather frequent misrepresentation of the nature of the drugs that are being sold.

Group therapy has been reestablished as a specific treatment program for carefully selected patients and seemingly has been successful in meeting their needs. Dr. Ben A. Green, Jr., a behavioral psychologist, has been working with the psychiatrists in applying behavioral therapy to specific symptom complexes.

The utilization statistics for the Psychiatric Service are given in Table II. There was an 8 per cent rise in the number of different patients seen

in 1970-1971 when compared with 1969-1970; the total number of visits rose 28 per cent for this same period. Our median number of visits is now 1.0 and our mean is 2.6. Seventy-five foreign students from 38 countries were seen this year, as compared with 57 students from 33 countries last year. The number of outside clinic referrals was about the same as last year, while the referrals to private physicians were about two-thirds those of last year. There was a drop in the number of patients using the Infirmary from 45 last year to 35 this year, and a 35 per cent decrease in patient days of Infirmary occupancy, from 316 last year to 204 this year. Part of this reduction is, of course, due to the extended closure of the Infirmary last summer and early fall, during the move to its new location, but insofar as we only hospitalized 10 patients (compared with 17 last year) it clearly reflects the improved effectiveness and ingenuity of the staff in maintaining people as active, functioning members of the M.I.T. Community.

SOCIAL WORK SERVICE

There were 953 visits during the year, representing an increase of 19 per cent over the previous year. There were 241 people who consulted the Service for the first time, representing all categories of the Institute Community. Among this group, there were 17 faculty, 31 staff, and 57 employees. Many student families and employees presented problems that reflected concern about their economic situation and anxiety about job security or job opportunities. Mrs. Myra Rodrigues joined our Social Work Service in February, 1971, and her skills based on a background both in case work and community work are a valuable addition to the Service.

INFIRMARY

The old Infirmary in the Homberg Memorial Building closed early in June 1970 and did not reopen in the renovated Sancta Maria Building until early September. For the first month, admissions were limited in order to allow completion of the building program. As a result, 1970-1971 Infirmary admissions were down nearly 20 per cent from recent years. Disregarding the first four months of each year, 1970-1971 admissions (474) were only one less than 1969-1970 admissions (475). Infirmary statistics are given in Table III.

Again, non-specific viral illness (21 per cent) led the list of Infirmary discharge diagnoses, gastroenteritis of all kinds was responsible for 14 per cent of our admissions, and infectious mononucleosis for 6 per cent. These figures do not differ from the previous diagnosis patterns.

With the move to new quarters, great changes have been made in

Infirmary standards. Among these have been excellent new equipment of all kinds, including electric beds, new patient furniture in all areas, a small but modern pharmacy, separation of the Emergency Clinic from the patient bed care areas, and a sharing of facilities with the expanded Dental Clinic and the new Pediatric Clinic. Food service problems have continued to be the most difficult and least satisfactory of all the changes. Use of food holding equipment has not been altogether satisfactory, and we may have to return to old fashioned methods of food service and delivery.

CLINICAL LABORATORY, ELECTROCARDIOGRAPHY, X-RAY

We continue to have our clinical laboratory work performed by the Commonwealth Clinical Laboratory. The total number of tests performed was 35,313, an increase of 10 per cent over the previous year. In addition, 252 special blood lipid determinations were performed at the M.I.T. Clinical Research Center through the courtesy of the Director, Dr. Robert S. Lees.

There were 9,909 x-ray films taken during the year, representing an increase of about 4 per cent. The number of electrocardiograms taken was 1,478, slightly fewer than last year.

SANITATION

Routine bacteriological monitoring of the M.I.T. food services and swimming pool continues to be handled by the Massachusetts Dairy Laboratories. Mr. Fred E. Smith, our Consultant Sanitary Engineer, reviews the bacteriological reports and inspects the facilities monthly, or if necessary, more often. There were no outbreaks of food borne infection during the year. An occasional sample of milk or cream had higher bacterial counts than desirable, emphasizing the need for great care in handling these easily contaminated products.

STUDENT HEALTH INSURANCE

For the second year, all regular M.I.T. students were required to pay a Health Service fee which covered all diagnostic and therapeutic care given by the Medical Department, including hospitalization in the M.I.T. Infirmary. A commercial hospital and accident insurance was offered but was optional, although the students were urged to subscribe unless they had other insurance that provided equivalent coverage. Unfortunately, as was true last year, several students with major hospital expenses proved to have either no coverage or grossly inadequate coverage. While we recognize that a compulsory hospital and accident insurance in many cases would result in duplicate coverage, we are very disturbed about the major financial problems that the unprotected student

may bring upon himself and the hospital in case of serious accident or illness and recommend that hospital and accident insurance be made compulsory.

ENVIRONMENTAL MEDICAL SERVICE

Dr. Harriet L. Hardy, Assistant Medical Director in Charge of the Environmental Medical Service, retired at the end of this year. During the 23 years of her dynamic leadership, the Environmental Medical Service has developed into a very sophisticated organization made up of 11 staff members, 14 technicians, an administrative assistant, and 5 secretaries. In addition to its primary function of protecting M.I.T. and its environment from an extraordinary variety of potential hazards, the Service has become recognized as a national resource. The current interest in environmental pollution is reflected in the increasing number of calls for advice that are directed to various staff members. Civic groups, industry, state and Federal agencies, other academic institutions, unions, hospitals and news media have sought advice during the year.

In general, the activity of the Radiation Protection Group was unchanged during the year. The decreased use of particle accelerators on campus and the phase out of the Nuclear Inorganic Group of the Department of Chemistry was offset in radiation protection requirements by the increased use of isotopes in various departments and the need for radiation protection service for the 400 MeV Linear Accelerator (LINAC) in Middleton, Massachusetts. One laboratory of the Nuclear Inorganic Chemistry complex in Building NW13 is equipped with a pneumatic tube system for reactor irradiations. The Environmental Medical Service has accepted the responsibility for this important facility so that it can be maintained for use by any Department of the Institute.

The Industrial Hygiene Office work has also continued essentially unchanged insofar as its regular operations are concerned. The respiratory protection, hearing protection, and laboratory hood programs are not only essential monitoring operations, but keep various members of the staff active in all parts of the Institute where they may discover new potential hazards which require attention. The introduction of oncogenic viruses has posed some difficult problems, and will require the design of a special biological cabinet, as those available are not satisfactory. The Industrial Hygiene Office has been devoting a great deal of time to ventilation and air cleaning problems involved in the design of the new Electrical Engineering Building and the renovations of Building 6. During the year, a final balance of the laboratory hood systems in the new Chemistry Building was completed.

ALBERT O. SEELER, M.D.

Table I

Clinic Visits	June 1, 1969-May 31, 1970	June 1, 1970-May 31, 1971
Medical	25,655	29,274
Surgical	10,326	10,784
Other	25,747	31,555
TOTAL	**61,728**	**71,613**
Faculty	3,617	3,446
Staff	6,298	7,094
Employees	12,235	16,405
Students	32,469	35,300
Student wives	5,188	5,637
Other	1,921	3,731
TOTAL	**61,728**	**71,613**

Table II Psychiatric Service June 1, 1970-May 31, 1971

Total individuals seen:	1,428
Total number of visits:	5,080

Analysis of Caseload:	Number of Patients Seen	Size of Class
Freshman	84	951
Sophomore	123	1,027
Junior	183	1,011
Senior	193	1,131
Special*	11	444
Uncertain	53	41
Graduates	224	3,296
Faculty	40	
Staff	99	
Employee	136	
Faculty Health Survey	14	
Other	151	
Alumni**	117	

Total number of patients hospitalized	10
Total number of patients referred to clinic	27
to private doctor	38
Total number of patients using the Infirmary	35
Total number of patient days of Infirmary occupancy	204

* Combined graduate and undergraduate
** Includes Class of 1970

Table III

Infirmary Admissions:	June 1, 1969-May 31, 1970	Sept. 8, 1970-May 31, 1971
Medical	443	372
Surgical	112	99
Psychiatric	59	35
TOTAL	**614**	**506**
Patient Days:		
Faculty	38	66
Staff	101	66
Employees	260	174
Students	2,235	1,847
Student wives	124	134
Other	41	2
TOTAL	**2,799**	**2,289**

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	1900–01	1,277	1935–36	2,540
1866–67	137	1901–02	1,415	1936–37	2,793
1867–68	167	1902–03	1,608	1937–38	2,966
1868–69	172	1903–04	1,528	1938–39	3,093
1869–70	206	1904–05	1,561	1939–40	3,100
1870–71	224	1905–06	1,466	1940–41	3,138
1871–72	261	1906–07	1,397	1941–42	3,055
1872–73	348	1907–08	1,415	1942–43	3,048
1873–74	276	1908–09	1,461	1943–44	1,579
1874–75	248	1909–10	1,479	1944–45	1,198
1875–76	255	1910–11	1,506	1945–46	1,538
1876–77	215	1911–12	1,559	1946–47	5,172
1877–78	194	1912–13	1,611	1947–48	5,662
1878–79	188	1913–14	1,685	1948–49	5,433
1879–80	203	1914–15	1,816	1949–50	5,458
1880–81	253	1915–16	1,900	1950–51	5,171
1881–82	302	1916–17	1,957	1951–52	4,874
1882–83	368	1917–18	1,698	1952–53	5,074
1883–84	443	1918–19	1,819	1953–54	5,183
1884–85	579	1919–20	3,078	1954–55	5,348
1885–86	609	1920–21	3,436	1955–56	5,648
1886–87	637	1921–22	3,505	1956–57	6,000
1887–88	720	1922–23	3,180	1957–58	6,179
1888–89	827	1923–24	2,949	1958–59	6,259
1889–90	909	1924–25	2,938	1959–60	6,270
1890–91	937	1925–26	2,813	1960–61	6,289
1891–92	1,011	1926–27	2,671	1961–62	6,454
1892–93	1,060	1927–28	2,712	1962–63	6,695
1893–94	1,157	1928–29	2,868	1963–64	6,925
1894–95	1,183	1929–30	3,066	1964–65	7,151
1895–96	1,187	1930–31	3,209	1965–66	7,408
1896–97	1,198	1931–32	3,188	1966–67	7,567
1897–98	1,198	1932–33	2,831	1967–68	7,730
1898–99	1,171	1933–34	2,606	1968–69	7,764
1899–00	1,178	1934–35	2,507	1969–70	8,024
				1970–71	7,799

* From 1943 to 1946 Army and Navy students are omitted (see Table 3-B in reports for 1943 to 1946).

Table I-A. Student Registration in the Summer Session since 1948

Year	*In Regular Subjects	†In Other Subjects	Year	*In Regular Subjects	†In Other Subjects
1948	2,146	—	1959	1,635	1,510
1949	1,875	171	1960	1,600	1,696
1950	1,852	259	1961	1,668	1,412
1951	1,861	813	1962	1,748	1,763
1952	1,689	832	1963	1,808	1,397
1953	1,672	1,289	1964	1,882	1,492
1954	1,675	1,398	1965	2,090	1,568
1955	1,619	1,653	1966	2,054	1,787
1956	1,553	2,497	1967	2,218	1,829
1957	1,548	1,757	1968	2,490	1,842
1958	1,650	1,752	1969	2,241	1,938
			1970	2,185	1,666

* Students attending regular subjects from M.I.T. curricula.

† Students attending professional and technical subjects which are not part of M.I.T. curricula and in general carry no academic credit.

Table II. The Academic Staff

	Professors	Administration also Professors	Associate Professors	Assistant Professors	Lecturers*	Sr. Research Scientists	Instructors	Technical Instructors	Research Associates	Technical Assistants	Research Assistants	Teaching Assistants	**Total**	Professors Emeriti	Visiting Professors	Others[1]
School of Architecture and Planning																
Architecture	7	2	9	14	4	—	6	2	2	—	17	3	66	3	5	1
Urban Studies and Planning	6	2	6	2	8	—	2	—	4	—	7	14	51	—	2	5
Total	**13**	**4**	**15**	**16**	**12**	**—**	**8**	**2**	**6**	**—**	**24**	**17**	**117**	**3**	**7**	**6**
School of Engineering																
Aeronautics and Astronautics	21	5	11	12	10	—	1	2	6	—	102	1	**171**	3	4	14
Chemical Engineering	8	3	4	8	1	—	4	3	4	—	30	29	**94**	5	2	1
Civil Engineering	10	1	20	17	6	—	1	2	6	—	96	16	**175**	3	5	9
Electrical Engineering	48	4	30	31	25	—	18	—	8	—	110	80	**354**	8	2	28
Mechanical Engineering	24	3	20	9	17	—	6	4	14	—	104	4	**205**	10	4	4
Metallurgy and Materials Science	15	1	8	6	1	—	—	2	5	—	67	27	**134**	5	2	15
Naval Architecture and Marine Engineering	11	1	5	4	3	—	3	—	—	—	22	8	**57**	1	—	6
Nuclear Engineering	11	1	5	4	—	—	—	—	5	—	27	22	**75**	—	1	—
School Professors	1	—	—	—	—	—	—	—	—	—	—	—	**1**	—	—	—
Total	**149**	**19**	**103**	**91**	**63**	**—**	**33**	**13**	**48**	**—**	**558**	**187**	**1,264**	**35**	**20**	**77**
School of Humanities and Social Science																
Economics	12	2	4	4	1	—	1	—	1	—	5	11	**41**	2	3	11
Foreign Literatures and Linguistics	5	2	6	2	5	—	7	—	1	—	2	3	**33**	3	—	14
Humanities	23	1	16	21	14	—	18	—	3	—	—	2	**98**	—	1	3
Political Science	12	1	6	4	4	—	3	—	1	1	6	8	**46**	—	5	2
Psychology	3	1	6	—	1	—	—	1	13	1	2	4	**32**	—	6	3
Total	**55**	**7**	**38**	**31**	**25**	**—**	**29**	**1**	**19**	**2**	**15**	**28**	**250**	**5**	**15**	**33**
Alfred P. Sloan School of Management																
Management	20	3	15	20	17	—	5	—	10	8	38	35	**171**	3	9	3

School of Science																
Biology	12	4	8	7	1	1	—	—	45	35	7	13	**133**	2	6	36
Chemistry	19	3	10	5	9	1	3	—	51	16	82	86	**285**	12	1	26
Earth and Planetary Sciences	8	1	5	8	1	—	—	—	16	—	41	9	**89**	3	1	3
Mathematics	34	2	10	7	—	—	42	—	5	4	13	50	**167**	3	—	1
Meteorology	7	2	1	2	2	—	—	—	6	1	32	8	**61**	1	—	1
Nutrition and Food Science	9	3	11	7	8	—	1	—	31	21	37	1	**129**	1	3	9
Physics	51	4	19	23	6	8	7	4	1	—	118	44	**285**	4	8	30
Total	**140**	**19**	**64**	**59**	**27**	**10**	**53**	**4**	**155**	**77**	**330**	**211**	**1,149**	**26**	**27**	**113**
Miscellaneous																
Aerospace Studies	—	1	—	—	—	—	4	2	—	—	—	—	**7**	—	—	—
Athletic	—	1	5	7	—	—	9	—	—	—	—	—	**22**	—	—	—
Medical	—	3	—	—	—	—	—	—	—	—	—	—	**3**	—	—	—
Military Science	—	1	—	—	—	—	2	3	—	—	—	—	**6**	—	—	—
Naval Science	—	1	—	—	—	—	3	4	—	—	—	—	**8**	—	—	—
Institute Professors	13	1	—	—	—	—	—	—	—	—	—	—	**14**	2	3	—
Administration	—	1	—	—	1	—	—	—	—	—	—	—	**2**	3	—	—
Center for Advanced Visual Studies	—	—	—	—	—	—	—	—	—	—	—	—	**—**	—	—	12
Center for International Studies	—	—	—	—	—	2	—	—	—	—	—	—	**2**	—	—	8
Center for Materials Science and Engineering	—	—	—	—	—	—	—	—	—	—	—	—	**—**	—	—	2
Center for Space Research	—	—	—	—	—	—	—	—	—	—	—	—	**—**	—	—	9
Education Research Center	—	—	—	—	—	—	—	—	—	—	—	—	**—**	—	—	1
Laboratory for Nuclear Science	—	—	—	—	—	—	—	—	—	—	—	—	**—**	—	—	2
National Magnet Laboratory	—	—	—	—	—	—	—	—	—	—	—	—	**—**	—	—	2
Research Laboratory of Electronics	—	—	—	—	—	—	—	—	—	—	—	—	**—**	—	—	32
Urban Systems Laboratory	—	—	—	—	—	—	—	—	4	—	—	—	**4**	—	—	—
Total	**13**	**9**	**5**	**7**	**1**	**2**	**18**	**9**	**4**	**—**	**—**	**—**	**68**	**5**	**3**	**68**
Grand Total	**390**[2]	**61**[2]	**240**[2]	**224**[2]	**145**[2]	**12**	**146**[2]	**29**[2]	**242**[3]	**87**	**965**	**478**[2]	**3,019**	**77**[4]	**81**[4]	**367**[4]
Faculty *ex officio*													**37**			
													3,056			

The total faculty is 982.

* Lecturers include 25 professors and 4 associate professors emeriti.

1 Includes guests, visiting lecturers, visiting instructors, visiting scientists, visiting social scientists, visiting engineers, research affiliates, postdoctoral associates, and fellows.

2 Total teaching staff is 1713. 3 One faculty and 241 non-faculty. 4 Not included in preceding total.

Table III. Classification of Students since 1968

Course	1968-69 2	3	4	G	Total	1969-70 2	3	4	G	Total	1970-71 2	3	4	G	Total	Course Number
chool of Architecture and Planning																
rchitecture (IV)	40	27	6	82	155	50	56	27	97	230	40	59	54	135	288	IV
rchitecture (IV-A)	—	—	8	—	8	—	—	—	—	—	—	—	—	—	—	IV-A
Fifth Year	—	—	20	—	20	—	—	9	—	9	—	—	2	—	2	Fifth Year
rchitecture (IV-B)	—	—	—	—	—	—	1	—	—	—	—	1	1	—	2	IV-B
rban Studies and Planning (XI)[2]	—	—	—	112	112	—	—	—	138	138	10	15	7	129	161	XI
otal	**40**	**27**	**34**	**194**	**295**	**50**	**57**	**36**	**235**	**378**	**50**	**75**	**64**	**264**	**453**	**Total**
chool of Engineering																
eronautics and Astronautics (XVI)	59	60	73	226	418	47	45	60	242	394	27	35	49	213	324	XVI
eronautics and Astronautics (XVI-B) (Cooperative)	—	15	4	—	19	—	5	15	—	20	—	2	10	—	12	XVI-B
hemical Engineering (X)	27	35	36	117	215	26	25	36	127	214	30	37	22	149	238	X
hemical Engineering (X-C)	—	—	—	—	—	—	—	—	—	—	3	—	—	—	3	X-C
ivil Engineering (I)	16	30	22	191	259	29	32	33	197	291	20	48	31	213	312	I
ectrical Engineering (VI-1)	171	167	151			140	165	175			127	119	187			
ectrical Science and Engineering (VI-2)	36	39	52	543	1,159	2	29	40	545	1,121	—	—	33	476	1,069	VI
ectrical Engineering (VI-3) (Computer Science)	—	—	—			25	—	—			52	69	6			
lectrical Engineering (VI-A) (Cooperative)	—	38	49	40	127	—	33	40	38	111	—	28	42	38	108	VI-A
lechanical Engineering (II)	41	60	63	246	410	35	52	62	242	391	29	37	53	236	355	II
lechanical Engineering (II-A)	—	—	—	—	—	1	5	3	—	9	1	15	18	—	34	II-A
lechanical Engineering (II-B) (Cooperative)	—	—	3	—	3	1	—	1	—	2	—	1	—	1	1	II-B
extile Technology (II-T)	—	—	—	14	14	—	—	—	11	11	—	—	—	10	10	II-T
letallurgy and Materials Science (III, III-A)	12	19	24	169	224	18	15	20	151	204	6	26	15	146	193	III, III-A
aval Architecture and Marine Engineering (XIII)	6	4	9	66	85	6	5	3	71	85	7	5	3	59	74	XIII
laval Construction and Engineering (XIII-A)	—		—	78	78	—	—	—	73	73	—	—	—	65	65	XIII-A
laval Architecture and Marine Engineering (XIII-W) (Woods Hole)	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	XIII-W
luclear Engineering (XXII)	—	—	—	130	130	—	—	—	128	128	—	—	—	114	114	XXII
hipping and Shipbuilding Management (XIII-B)	—	—	—	1	1	—	—	2	3	5	—	—	—	3	3	XIII-B
enter for Advanced Engineering Study (EN)	—	—	—	50	50	—	—	—	38	38	—	—	—	31	31	EN
otal	**368**	**467**	**486**	**1,871**	**3,192**	**330**	**411**	**490**	**1,866**	**3,097**	**302**	**422**	**469**	**1,754**	**2,947**	**Total**

hool of Humanities and Social Science																		
onomics (XIV)		15	25	40	125	205		11	22	35	129	197		14	22	31	103	170	XIV
reign Literatures and Linguistics XXIII)[3]		—	—	—	39	39		—	—	—	45	45		—	—	—	39	39	XXIII
manities and Engineering (XXI-A)		3	14	10	25	194		2	6	29	34	236		5	5	15	38	209	XXI
manities and Science (XXI-B)		32	50	60				31	63	71				14	55	77			
itical Science (XVII)		11	23	33	87	154		12	32	41	91	176		2	19	40	82	143	XVII
chology (IX)		—	—	—	29	29		—	—	—	30	30		—	—	—	25	25	IX
tal		**61**	**112**	**143**	**305**	**621**		**56**	**123**	**176**	**329**	**684**		**35**	**101**	**163**	**287**	**586**	**Total**
fred P. Sloan School of Management																			
nagement (XV)		23	51	72	353	499		15	52	72	393	532		26	48	69	355	498	XV
hool of Science																			
logy (VII)		47	49	44	115	255		42	61	45	119	267		66	73	67	117	323	VII
logy (VII-W) (Woods Hole)		—	—	—	—	—		—	—	—	—	—		—	—	—	1	1	VII-W
emistry (V)		27	24	44	295	390		37	34	30	275	376		43	48	37	251	379	V
th and Planetary Sciences XII, XII-A)[4]		9	10	14	90	123		17	14	11	106	148		20	16	18	73	127	XII, XII-A
th and Planetary Sciences (XII-W) Woods Hole)		—	—	—	—	—		—	—	—	—	—		—	—	—	24	24	XII-W
sical Sciences (XII-B)		10	5	1	—	16		11	14	7	—	32		3	14	14	—	31	XII-B
thematics (XVIII)		75	101	92	134	402		72	91	106	149	418		88	89	88	134	399	XVIII
teorology (XIX)		—	—	—	69	69		—	—	—	65	65		—	—	—	43	43	XIX
teorology (XIX-W) (Woods Hole)		—	—	—	—	—		—	—	—	—	—		—	—	—	15	15	XIX-W
trition and Food Science (XX)		—	—	—	93	93		—	—	—	113	113		—	—	—	103	103	XX
sics (VIII)		142	118	118	290	665		124	151	103	300	678		99	125	142	258	624	VIII
tal		**310**	**304**	**313**	**1,086**	**2,013**		**303**	**365**	**302**	**1,127**	**2,097**		**319**	**363**	**366**	**1,029**	**2,069**	**Total**
designated		171				171		269				269		295				295	Undesignated
st Year Students	973					973	967					967	951					951	First Year
and Total	**973**	**973**	**961**	**1,048**[1]	**3,809**	**7,764**	**967**	**1,023**	**1,008**[5]	**1,076**[1,5]	**3,950**	**8,024**	**951**	**1,027**	**1,011**[6]	**1,131**[1,6]	**3,679**	**7,799**	**Grand Total**
(Not included in above figures)																			
n-Institute Students from Harvard		1	1	4	152	158		—	—	4	130	134		1	3	5	112	121	Non-Inst. H
n-Institute Students from Wellesley	1	16	18	55	—	90		—	54	57	—	141		46	93	109	4	252	Non-Inst. W
n-Institute[7]														2	—	1	1	4	Non-Inst.

is total includes Fifth Year in Architecture
ior to 1969-70 City and Regional Planning
ior to 1969-70 Modern Languages and Linguistics
ior to 1969-70 Geology and Geophysics
ese totals include 6 students in third year and 5 in fourth year on Foreign Study
iese totals include 10 students in third year and 2 in fourth year on Foreign Study
cludes 1 non-institute student from each of Boston College, Boston University, Brandeis University, University of Massachusetts

Table III-A. Women Students by Schools, Courses, and Years, 1970–71[1]

Course	Year				
	2	3	4	G	Total
School of Architecture and Planning					
Architecture (IV)	7	9	7	30	53
Urban Studies and Planning (XI)	1	1	—	29	31
Total	**8**	**10**	**7**	**59**	**84**
School of Engineering					
Aeronautics and Astronautics (XVI)	—	—	1	1	2
Chemical Engineering (X)	3	—	—	3	6
Civil Engineering (I)	1	4	3	10	18
Electrical Engineering (VI)	3	5	10	15	33
Mechanical Engineering (II)	2	1	1	4	8
Metallurgy and Materials Science (III)	1	1	2	4	8
Naval Architecture and Marine Engineering (XIII)	—	—	—	1	1
Nuclear Engineering (XXII)	—	—	—	2	2
Total	**10**	**11**	**17**	**40**	**78**
School of Humanities and Social Science					
Economics (XIV)	—	4	3	10	17
Foreign Literatures and Linguistics (XXIII)	—	—	—	14	14
Humanities and Engineering or Science (XXI-A, XXI-B)	1	11	6	10	28
Political Science (XVII)	—	1	3	15	19
Psychology (IX)	—	—	—	8	8
Total	**1**	**16**	**12**	**57**	**86**
Alfred P. Sloan School of Management					
Management (XV)	2	2	1	20	25
School of Science					
Biology (VII)	14	10	9	41	74
Chemistry (V)	8	3	4	31	46
Earth and Planetary Sciences (XII-XII-W)	1	2	1	3	7
Physical Sciences (XII-B)	1	—	1	—	2
Mathematics (XVIII)	15	6	5	6	32
Meteorology (XIX, XIX-W)	—	—	—	2	2
Nutrition and Food Science (XX)	—	—	—	24	24
Physics (VIII)	7	6	3	7	23
Total	**46**	**27**	**23**	**114**	**210**
Undesignated	34	—	—	—	34
First-Year Students 87	—	—	—	—	87
Grand Total 87	101	66	60	290	604

[1] Included also in Table III

Table III-B. Special Students by Schools, Courses, and Years, 1970–71[1]

Course	Year				
	2	3	4	G	Total
School of Architecture and Planning					
Architecture (IV)	—	—	—	20	20
Urban Studies and Planning (XI)	—	—	1	29	30
Total	—	—	1	49	50
School of Engineering					
Aeronautics and Astronautics (XVI)	—	—	—	36	36
Chemical Engineering (X)	1	—	—	3	4
Civil Engineering (I)	—	1	—	21	22
Electrical Engineering (VI, VI-3)	—	1	2	98	101
Mechanical Engineering (II)	—	1	—	18	19
Metallurgy and Materials Science (III)	—	—	—	6	6
Naval Architecture and Marine Engineering (XIII)	—	—	—	6	6
Nuclear Engineering (XXII)	—	—	—	2	2
Center for Advanced Engineering Study (EN)	—	—	—	31	31
Total	1	3	2	221	227
School of Humanities and Social Science					
Economics (XIV)	—	—	1	7	8
Foreign Literatures and Linguistics (XXIII)	—	—	—	5	5
Humanities and Engineering or Science (XXI)	—	—	—	4	4
Political Science (XVII)	—	—	2	17	19
Psychology (IX)	—	—	—	1	1
Total	—	—	3	34	37
Alfred P. Sloan School of Management					
Management (XV)	—	2	—	33	35
School of Science					
Biology (VII)	—	—	—	18	18
Chemistry (V)	—	1	—	2	3
Earth and Planetary Sciences (XII)	1	—	—	4	5
Mathematics (XVIII)	1	1	—	7	9
Meteorology (XIX)	—	—	—	4	4
Nutrition and Food Science (XX)	—	—	—	5	5
Physics (VIII)	2	—	1	6	9
Total	4	2	1	46	53
Undesignated	41	—	—	—	41
First-Year Students	1 —	—	—	—	1
Grand Total	1 46	7	7	383	444

[1] Included also in Table III

Table IV. Continued, Former, and New Students

	1966–67	1967–68	1968–69	1969–70	1970–71
Continued Students					
Undergraduate and graduate students registered at the end of the last academic year (including Special Students)	5,201	5,368	5,426	5,471	5,474
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)	264	225	260	308	304
Undergraduate students who enrolled for the first time since secondary school (excluding Special Students)	922	912	963	956	942
Undergraduate students who enrolled for the first time at the Institute and who transferred from another collegiate institution (excluding Special Students)	71	75	85	98	102
Graduate students who enrolled for the first time at the Institute (excluding Special Students)	840	890	756	883	759
Special Undergraduate and Graduate Students with no previous Institute registration	269	260	274	308	218
Total	**7,567**	**7,730**	**7,764**	**8,024**	**7,799**

Table V. Regular Students from Other Colleges and Graduates of M.I.T. Classified by Schools and Courses, 1970–1971

	Entered with no previous degree	Entered with Bachelor's degree from other colleges		Entered Graduate School with Bachelor's degree from M.I.T.
		Under-graduate	Graduate	
School of Architecture and Planning				
Architecture (IV, IV-A)	25	—	100	15
Urban Studies and Planning (XI)	—	—	89	11
Total	**25**	**—**	**189**	**26**
School of Engineering				
Aeronautics and Astronautics (XVI)	15	—	123	54
Chemical Engineering (X)	10	—	111	35
Civil Engineering (I)	9	—	153	39
Electrical Engineering (VI-1, VI-2, VI-3, VI-A)	59	1	199	217
Mechanical Engineering (II, II-T)	9	—	174	54
Metallurgy and Materials Science (III, III-A)	3	—	99	41
Naval Architecture and Marine Engineering (XIII, XIII-W)	6	—	45	9
Naval Construction and Engineering (XIII-A)	—	—	63	2
Nuclear Engineering (XXII)	—	—	100	12
Shipping and Shipbuilding Management (XIII-B)	—	—	2	1
Total	**111**	**1**	**1,069**	**464**
School of Humanities and Social Science				
Economics (XIV)	2	—	91	5
Foreign Literatures and Linguistics (XXIII)	—	—	32	2
Humanities and Engineering or Science (XXI-A, XXI-B)	4	—	34	—
Political Science (XVII)	1	—	59	6
Psychology (IX)	—	—	22	2
Total	**7**	**—**	**238**	**15**
Alfred P. Sloan School of Management				
Management (XV)	8	—	254	68
School of Science				
Biology (VII, VII-W)	15	—	95	5
Chemistry (V)	5	—	247	2
Earth and Planetary Sciences (XII, XII-A, XII-W)	2	—	79	14
Mathematics (XVIII)	26	—	103	24
Meteorology (XIX, XIX-W)	—	—	48	6
Nutrition and Food Science (XX)	—	—	83	15
Physics (VIII)	35	—	182	70
Total	**83**	**—**	**837**	**136**
Undesignated	1	—	—	—
First Year	2	—	—	—
Grand Total	**237**	**1**	**2,587**	**709**

Table VI. List of Colleges and Universities with Number of Graduates Entering the Institute as Regular Graduate Students, 1970–1971[1]

United States	
Agricultural, Mechanical and Normal College	1
American Institute for Foreign Trade	1
Auburn University	1
Bates College	1
Beaver College	1
Boston College	4
Boston University	4
Bowdoin College	1
Brandeis University	5
Brigham Young University	1
Brooklyn College	1
Brown University	7
Bucknell University	2
California, University of, Berkeley	12
California, University of, Davis	4
California, University of, L.A.	7
California, University of, Riverside	2
California, University of, Santa Barbara	1
California, University of, Santa Cruz	1
California Institute of Technology	4
California State Polytech College	2
Carleton College	1
Carnegie-Mellon University	4
Case Western Reserve University	2
Catholic University of America	1
Cheyene State College	1
Chicago, University of	3
Cincinnati, University of	1
City College, The	6
Clark University	2
Colby College	2
Colorado, University of	2
Colorado State University	2
Columbia University	12
Connecticut, University of	3
Cooper Union, The	7
Cornell University	21
Dartmouth College	3
Dayton, University of	1
Delaware, University of	2
Delaware State College	2
Denver University	1
Detroit, University of	2
Drexel Institute of Technology	1
Drake University	1
Duke University	2
Eastern Illinois University	1
Fairleigh Dickinson University	1
Florida, University of	4
Florida State University	2
Fiske University	1
Fordham University	4
Fresno State College	1
General Motors Institute	5
Georgetown University	1
George Washington University	2
Georgia Institute of Technology	3
Georgia State University	1
Gonzaga University	1
Goucher College	2
Hamilton College	2
Hampton Institute	4
Harvard University	14
Harvey Mudd College	6
Haverford College	1
Hawaii, University of	2
Hebrew University	1
Hofstra, New College of	1
Holy Cross, College of the	1
Howard University	3
Hunter College	2
Illinois, University of	16
Illinois Institute of Technology	3
Indiana University	2
Iowa, University of at Iowa City	1
Iowa State University	2
Johns Hopkins University	5
Juniata College	1
Kansas, University of	1
Kansas State University	2
Lamar State College of Technology	1
Lawrence University	1
Lehigh University	6
Lowell Technological Institute	4
Loyola University	1
Maine, University of	1
Maryknoll Seminary at Ossining	1
Massachusetts, University of	5
Massachusetts College of Pharmacy	1
Massachusetts Institute of Technology	203
Merrimack College	1
Miami University	2
Michigan, University of	14
Michigan State University	5
Mills College	1
Minnesota, University of	7
Minnesota, University of, at Duluth	1
Missouri, University of, at Columbia	2
Missouri, University of, at Rolla	3
Missouri, University of, at St. Louis	1
Montana University of Mining and Technology	1
Morehead State College	1
Morgan State College	2
New Hampshire, University of	2
Newark College of Engineering	2
New Mexico, University of	2
New Mexico University of Mining and Technology	1
New York University	7
New York State University at Buffalo	2
North Carolina, University of	1
North Carolina State University at Raleigh	2
Northeastern University	17

[1] Graduates of 179 Colleges and Universities in the United States and 127 Foreign Colleges entered the Institute.

Northwestern University	1
Notre Dame, University of	7
Oberlin College	1
Ohio, University of	2
Ohio State University	1
Oklahoma, University of	1
Oregon, University of	2
Oregon State University	3
Pennsylvania, University of	9
Pennsylvania State University	4
Polytech. Institute of Brooklyn	4
Pomona College	1
Pratt Institute	2
Princeton University	14
Purdue University	11
Queens College	1
Radcliffe College	1
Reed College	1
Rensselaer Polytechnic Institute	12
Rhode Island School of Design	1
Rochester Institute of Technology	1
Rochester, University of	4
Rutgers, The State University	3
St. Joseph's College	1
San Diego State College	1
San Jose State College	1
Savannah State College	1
Siena College	1
Simmons College	1
Smith College	3
Southeastern Massachusetts University	1
Southern California, University of	1
Stanford University	6
Stevens Institute of Technology	6
Swarthmore College	3
Syracuse University	2
Tennessee, University of	2
Texas, University of, at Austin	6
Texas Agricultural and Mechanical University	2
Toledo, University of	3
Tufts University	7
Tulane University	1
Union College and University	1
U. S. Air Force Academy	4
U. S. Coast Guard Academy	3
U. S. Military Academy	12
U. S. Naval Academy	19
U. S. Naval Postgraduate School	2
Ursinus College	1
Utah, University of	1
Valparaiso University	1
Vermont, University of	1
Virginia, University of	1
Virginia Polytechnic Institute	4
Wabash College	2
Washington, University of	4
Wayne State University	2
Webb Institute of Naval Architecture	1
Wellesley College	3
Wesleyan University	1
West Virginia University	1
Whitman College	1
Williams College	2
Wisconsin, University of	7
Worcester Polytechnic Institute	3
Yale University	7
Yeshiva University	1
Total U. S.	**769**

Foreign

Adelaide, University of (Australia)	1
Alexandria, University of (United Arab Republic)	1
American University of Beirut (Lebanon)	2
Barcelona, University of (Spain)	1
Birla Institute of Technology and Science (India)	3
Bombay, University of (India)	1
British Columbia, University of (Canada)	2
Calcutta, University of (India)	1
Cambridge University (England)	3
Ceske Vysoke Ucchi Technicke (Czechoslovakia)	1
Chung-Yuan Institute of Technology (Republic of China)	1
Chung-Yuan College of Sciences and Engineering (Republic of China)	2
Colegio de Agricultura y Artes Mechanicas, Mayaguez (Puerto Rico)	1
Deniz Harb Okulu (Turkey)	2
Dublin, University of (Ireland)	1
Ecole Centrales des Arts et Manufactures (France)	1
Ecole Centrale Lyonnaise (France)	1
Ecole Centrale de Paris (France)	1
Ecole de Mines (Nance, France)	1
Ecole des Hautes Etudes Commercials (France)	1
Ecole des Metiers (Switzerland)	1
Ecole Nacionale de la Statistique et d'Administration (France)	2
Ecole Nationale des Ponts et Jouy-en-Josas (France)	1
Ecole Nationale Superieure des Beaux Arts (France)	1
Ecole Nationale Superieure de Ceramique (France)	1
Ecole Superieure de Chime Industrielle de Lyon (France)	1
Ecole Superieure de Commerce et d'Administration des Enterprises (France)	1
Ecole Nationale Superieure d'Electricite (France)	1
Ecole Nationale Superieure des Arts et Metiers (France)	1
Ecole Polytechnique (France)	3
Edinburgh University (Scotland)	1
Eidgenossiche Technische Hoshschule (Switzerland)	1
Escuella Technica Superior de Ingenieros de Caminos (Spain)	2
Escola Naval (Portugal)	2
Faculte des Sciences Agronomiques de L'Etat (Belgium)	1
Faculte Polytechnique de Tehran (Belgium)	1
Geio Gi Juka Daigaku (Japan)	1
Ghana, University of (Ghana)	1

Greek Naval Academy (Greece)	1
Guelph, University of (Canada)	1
Gujarat University (India)	1
Ha-Universita-Ha Iurit (Israel)	1
Hitot Subashi Daigaku (Japan)	1
Imperial College of Science and Technology (England)	1
Indian Institute of Technology (Bombay, India)	4
Indian Institute of Technology (Khanpur, India)	1
Indian Institute of Technology (Kharagpur, India)	1
Indian Institute of Technology (New Delhi, India)	4
Instututo Militar de Engenharia (Brazil)	1
Institut National Agronomique (France)	1
Institut National des Sciences Appliquees de Lyon (France)	1
Instituto Superior Technico (Portugal)	1
Instituto Tegnologico de Aeronautica (Brazil)	2
Instituto Tecnology y de Estu, Monterrey, Neuvo Leon (Mexico)	1
Istanbul Teknik University (Turkey)	2
Karachi, University of (Pakistan)	1
Kiungliga Universitet I Stockholm (Sweden)	1
Kings College (England)	1
Kyota Daigaku (Japan)	2
Kyota Gaikokugo Daigaku (Japan)	1
Kyota Daigaku Kogei Sen. I (Japan)	1
Laval Universite (Canada)	1
Liverpool, University of (England)	1
Maharaja Sayajitao, University of (India)	1
Mapu Institute of Technology (Philippines)	1
McGill University (Canada)	10
Monash University (Australia)	1
Montreal, University of (Canada)	4
National Taiwan University (Republic of China)	4
National Chiao-Tung University (Republic of China)	1
Nottingham, University of (England)	1
Oxford University (England)	3
Pakistan Air Force College of Aeronautical Engineering (Pakistan)	1
Paris, Universite de (France)	1
Politechnico di Torino (Italy)	1
Polytechneion (Greece)	1
Pontificia Universidade Catolica (Brazil)	1
Poona University (India)	1
Pretoria, University of (So. Africa)	1
Puerto Rico, University de (Puerto Rico)	2
Rijksuniversiteit TeLeiden (Netherlands)	1
St. Andrews, University of (Scotland)	1
Sambalpur University (India)	1
Seoul National University (Korea)	4
Staatliche Ingenieurschule Frankfurt am Main (Germany)	1
Strasbourg, Universite de (France)	1
Surrey, University of (England)	1
Sussex, University of (England)	1
Swansea University (Wales)	1
Technion, The (Israel)	1
Technische Universitat (Hanover)	1
Technische Universitat Berlin (Germany)	1
Technische Universitat Munich (Germany)	1
Technology, College of (Ireland)	1
Tehran, University of (Iran)	1
Tel-Aviv University (Israel)	2
Tokyo Daigaku (Japan)	3
Tokyo Kogyo Daigaku (Japan)	2
Tokyo Kyoiku Daigaku (Japan)	1
Toronto, University of (Canada)	8
Univerzitet U Beogradu (Yugoslavia)	1
Universidad Catolico de Chile (Chile)	1
Universidad Catolico de Valparaiso (Chile)	2
Universidad Central de Venezuela (Venezuela)	2
Universidad de Chile (Chile)	2
University College (Ireland)	2
Universidad Federal Do Rio Grande Do Sul (Brazil)	1
Universidad Federal Do Rio de Janeiro (Brazil)	1
Universita di Firenze (Italy)	1
Universidad Iberoamericana (Mexico)	1
Universite de Louvain (Belgium)	1
University of Medical Science (Thailand)	1
Universidad Nacional Autonoma de Mexico (Mexico)	2
Universidad Nacional de Buenos Aires (Argentina)	1
Universidad Nacional de Columbia (Columbia)	3
Universidad Nacional de Ingenieria (Peru)	1
Universitet I Oslo (Norway)	1
Universita di Perugia (Italy)	1
Universidad de la Republice Oriental del Uruguay (Uruguay)	1
Universita di Roma (Italy)	1
Universidad de Sao Paulo (Brazil)	3
University of Science and Technology (Ghana)	1
Universita di Torino (Italy)	1
Universidad del Valle (Columbia)	1
Waterloo, University of (Canada)	3
Western Ontario, University of (Canada)	2
West Indies, University of (Jamaica)	1
Total Foreign	**193**
Grand Total Foreign & United States	**962**

Table VII. Geographic Distribution of Students, 1970–71

	Under-grad.	Grad.
United States:		
Alabama	21	13
Alaska	4	3
Arizona	14	8
Arkansas	10	8
California	173	161
Colorado	27	16
Connecticut	110	85
Delaware	18	8
District of Columbia	20	25
Florida	91	49
Georgia	41	14
Hawaii	30	4
Idaho	10	3
Illinois	175	103
Indiana	46	32
Iowa	21	13
Kansas	18	16
Kentucky	17	13
Louisiana	16	10
Maine	25	16
Maryland	144	62
Massachusetts	420	668
Michigan	88	62
Minnesota	40	28
Mississippi	5	9
Missouri	57	35
Montana	12	3
Nebraska	17	7
Nevada	3	2
New Hampshire	29	19
New Jersey	235	162
New Mexico	12	7
New York	805	453
North Carolina	26	16
North Dakota	—	2
Ohio	182	101
Oklahoma	19	12
Oregon	28	15
Pennsylvania	248	163
Rhode Island	20	18
South Carolina	14	9
South Dakota	8	6
Tennessee	33	12
Texas	107	59
Utah	7	16
Vermont	11	2
Virginia	89	59
Washington	40	25
West Virginia	10	7
Wisconsin	52	27
Wyoming	4	2
U. S. Territories and Dependencies:		
Puerto Rico	15	10
U.S. Citizens Foreign Address	51	45
Total U. S.	**3,718**	**2,723**
Foreign Countries*		
Algeria	—	1
Argentina	3	14
Australia	1	8
Austria	1	1
Bahama Islands	—	1
Belgium	1	8
Bermuda	1	1
Brazil	3	27
Burma	1	—
Cameroon	2	2
Canada	59	116
Ceylon	—	1
Chile	—	15
China, Republic of	36	79
Columbia	9	16
Costa Rica	2	—
Cuba	11	9
Cyprus	3	2
Czechoslovakia	4	4
Denmark	1	2
Dominican Republic	2	3
Ecuador	—	3
El Salvador	2	1
England	13	61
Ethiopia	4	—
Finland	3	2
France	2	49
Germany	3	20
Ghana	3	5
Greece	9	29
Guatemala	1	3
Haiti	—	1
Hong Kong	65	49
Hungary	—	3
Iceland	1	3
India	15	89
Indonesia	1	—
Iran	17	9
Iraq	1	2
Ireland	—	8
Israel	5	31
Italy	4	16
Ivory Coast	—	1
Jamaica	—	4
Japan	9	44
Jordan	—	4
Kenya	—	2
Korea	8	26
Kuwait	1	—
Lebanon	—	4
Libya	1	1
Lithuania	—	1
Luxembourg	—	1
Malaysia	7	6
Mexico	4	9
Morocco	1	—
Nepal	—	1
Netherlands	4	9
New Zealand	1	8
Nigeria	—	9
Norway	5	10
Pakistan	13	8
Peru	3	10
Philippines	1	5
Poland	6	2
Portugal	1	7
Rumania	3	1
Saudi Arabia	2	2
Sierra Leone	1	—
Singapore	—	4
South Africa, Republic of	1	3
Spain	1	9
Sweden	—	5
Switzerland	1	9
Tanzania	4	—
Thailand	10	10
Trinidad	—	1
Tunisia	—	1
Turkey	5	18
Uganda	—	1
United Arab Republic (Egypt)	1	11
Uruguay	2	2
Venezuela	8	15
Vietnam	2	2
Yugoslavia	1	8
Zambia	—	2
Stateless	6	5
Total Foreign	**402**	**956**
Grand Total	**4,120**	**3,679**

* Country of Citizenship

Table VIII. Number of Degrees Awarded in September 1970, February 1971, and June 1971

	S.B.			B.Arch.			S.M.			M.Arch. M.C.P.			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	2	15	—	—	—	1	1	16	—	—	—	—	—	—	—	—	—	3	3	31
Art and Design	1	1	41	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	41
Urban Studies and Planning	—	—	9	—	—	—	—	—	—	4	2	13	—	—	—	1	2	—	—	—	—	5	4	22
Undesignated	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Total	**1**	**1**	**51**	**2**	**2**	**15**	**—**	**—**	**—**	**5**	**3**	**29**	**—**	**—**	**—**	**1**	**2**	**—**	**—**	**—**	**—**	**9**	**8**	**95**
School of Engineering																								
Aeronautics and Astronautics	5	8	30	—	—	—	19	11	24	—	—	—	1	1	3	—	4	4	1	2	3	26	26	64
Ceramics	—	—	—	—	—	—	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	1	1	1
Chemical Engineering	1	4	15	—	—	—	1	5	19	—	—	—	1	1	4	—	2	3	4	3	5	7	15	46
Undesignated	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Chemical Engineering Practice	—	—	—	—	—	—	—	6	12	—	—	—	—	—	—	—	—	—	—	—	—	—	6	12
Civil Engineering	—	2	19	—	—	—	15	12	24	—	—	—	1	3	4	9	8	3	2	4	3	27	29	53
Undesignated	—	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8
Electrical Engineering	29	21	159	—	—	—	42	20	51	—	—	—	8	14	29	8	13	20	4	1	3	91	69	262
Mechanical Engineering	5	12	28	—	—	—	27	24	37	—	—	—	1	5	8	—	8	8	—	8	—	33	57	81
Undesignated	3	3	13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	3	13
Metallurgy and Materials Science	—	—	10	—	—	—	3	2	12	—	—	—	—	—	1	4	6	9	2	3	3	9	11	35
Undesignated	—	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4
Naval Architecture and Marine Engineering	1	—	5	—	—	—	1	1	16	—	—	—	3	—	21	1	—	3	—	—	1	6	1	46
Nuclear Engineering	—	—	—	—	—	—	9	12	3	—	—	—	—	1	—	2	3	1	2	1	1	13	17	5
Ocean Engineering	—	—	—	—	—	—	3	—	4	—	—	—	1	—	2	—	—	—	—	—	—	4	—	6
Shipping and Shipbuilding Management	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Textile Technology	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
Total	**45**	**50**	**292**	**—**	**—**	**—**	**121**	**95**	**205**	**—**	**—**	**—**	**16**	**25**	**72**	**24**	**44**	**51**	**15**	**22**	**19**	**221**	**236**	**639**

School of Humanities and Social Science																							
Economics	3	6	15	—	—	—	—	—	1	—	—	—	—	—	—	10	2	4	—	—	—	13	8	20
Humanities and Engineering	2	1	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	1	5
Humanities and Science	6	4	49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	4	49
Linguistics	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	4	2	—	—	—	—	4	2	1
Philosophy	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Political Science	1	2	17	—	—	—	8	—	4	—	—	—	—	—	—	5	3	3	—	—	—	14	5	24
Psychology	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	1	1	—	—	—	2	1	1
Total	**12**	**13**	**86**	**—**	**—**	**—**	**8**	**—**	**6**	**—**	**—**	**—**	**—**	**—**	**—**	**21**	**8**	**8**	**—**	**—**	**—**	**41**	**21**	**100**
Alfred P. Sloan School of Management																							
Management	3	8	58	—	—	—	18	17	137	—	—	—	—	—	—	4	3	5	—	—	—	25	28	200
School of Science																							
Biochemical Engineering	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Biochemistry	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—
Biology	—	—	—	—	—	—	1	2	1	—	—	—	—	—	—	6	3	4	—	—	—	7	5	5
Undesignated	—	1	11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	11
Chemistry	2	5	31	—	—	—	5	3	3	—	—	—	—	—	—	25	16	20	—	—	1	32	24	55
Earth and Planetary Sciences	—	1	15	—	—	—	3	—	3	—	—	—	—	—	—	2	1	4	—	—	—	5	2	22
Undesignated	—	1	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	15
Food Science and Technology	—	—	—	—	—	—	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2	—
Life Sciences	3	9	36	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	9	36
Mathematics	4	15	59	—	—	—	1	1	4	—	—	—	—	—	—	11	1	14	—	—	1	16	17	78
Meteorology	—	—	—	—	—	—	1	2	2	—	—	—	—	—	—	3	6	—	—	—	—	4	8	2
Nutrition and Food Science	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	2	4	—	1	2	3	3	6
Nutritional Biochemistry and Metabolism	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—
Oceanography	—	—	—	—	—	—	—	3	1	—	—	—	—	—	—	—	—	—	—	—	—	—	3	1
Physics	11	10	106	—	—	—	7	7	12	—	—	—	—	—	—	13	14	12	—	—	1	31	31	131
Total	**20**	**42**	**273**	**—**	**—**	**—**	**21**	**22**	**27**	**—**	**—**	**—**	**—**	**—**	**—**	**63**	**43**	**58**	**—**	**1**	**5**	**104**	**108**	**363**
Operations Research	—	—	—	—	—	—	—	2	5	—	—	—	—	—	—	—	—	—	—	—	—	—	2	5
Without Course Specification	—	—	—	—	—	—	19	10	20	—	—	—	—	—	—	—	—	—	—	—	—	19	10	20
Awarded jointly with Woods Hole Oceanographic Institute																							
Earth and Planetary Sciences	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—
Meteorology	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	1	1
Grand Total	**81**	**114**	**760**	**2**	**2**	**15**	**187**	**146**	**400**	**5**	**3**	**29**	**16**	**25**	**72**	**114**	**100**	**123**	**15**	**24**	**24**	**420**	**414**	**1,423**

Table IX. Number of Degrees of Bachelor of Science Awarded

All statistics are arranged by schools as of the current year. During the years 1868–1949 the general divisions were Architecture, Engineering, and Science. In 1950 the School of Humanities and Social Studies was established, and in 1951 the School of Industrial Management (after 1963 the Alfred P. Sloan School of Management) was added.

	Total by decades													Calendar year since 1967 (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–	Grand Total	1967	1968	1969	1970	1971*
School of Architecture and Planning[1]																		
Architecture	—	12	24	162	188	233	223	23	—	—	—	—	865	—	—	—	—	—
Architectural Engineering[2]	—	—	—	—	—	—	108	64	—	—	—	—	172	—	—	—	—	—
Art and Design	—	—	—	—	—	—	—	—	—	—	26	42	68	1	1	10	14	42
Undesignated	—	—	—	—	—	—	—	—	—	—	2	—	2	—	—	—	2	—
Urban Studies and Planning	—	—	—	—	—	—	—	—	—	—	—	9	9	—	—	—	—	9
Undesignated	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	1
Total	**—**	**12**	**24**	**162**	**188**	**233**	**331**	**87**	**—**	**—**	**28**	**52**	**1,117**	**1**	**1**	**10**	**16**	**52**
School of Engineering																		
Aeronautical Engineering	—	—	—	—	—	—	68	287	526	340	—	—	1,221	—	—	—	—	—
Aeronautics and Astronautics	—	—	—	—	—	—	—	—	—	55	556	38	649	62	74	65	57	38
Building Engineering and Construction	—	—	—	—	—	—	32	99	114	131	—	—	376	—	—	—	—	—
Chemical Engineering	—	—	—	91	123	372	571	434	740	726	421	19	3,497	35	21	23	26	19
Undesignated	—	—	—	—	—	—	—	—	—	—	3	1	4	—	—	—	3	1
Chemical Engineering Practice	—	—	—	—	—	—	99	90	95	108	1	—	393	—	—	—	—	—
Civil Engineering	12	84	86	256	407	504	653	284	272	457	252	21	3,288	33	30	18	16	21
Undesignated	—	—	—	—	—	—	—	—	—	—	7	8	15	—	—	1	6	8
Electrical Engineering (including VI-A)	—	—	72	335	349	468	1,000	719	1,218	1,518	1,941	180	7,800	193	151	198	189	180
Electrochemical Engineering[3]	—	—	—	—	28	84	133	56	—	—	—	—	301	—	—	—	—	—
General Engineering	—	—	—	—	—	6	226	222	230	133	—	—	817	—	—	—	—	—
Mechanical Engineering	5	40	147	329	502	623	797	602	1,164	1,049	563	40	5,861	61	40	40	44	40
Undesignated	—	—	—	—	—	—	—	—	—	—	12	16	28	—	—	2	10	16
Metallurgy and Materials Science[4]	—	—	—	—	—	—	—	52	194	311	186	10	753	16	10	20	12	10
Undesignated	—	—	—	—	—	—	—	—	—	—	1	4	5	—	—	—	1	4
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	5	965	11	4	8	3	5
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**	**342**	**27,122**	**411**	**330**	**375**	**367**	**342**

School of Humanities and Social Science																		
Economics	—	—	—	—	—	—	—	—	—	—	129	21	150	16	31	39	28	21
Economics, Politics and Engineering or Science	—	—	—	—	—	—	—	—	61	152	100	—	313	—	—	—	—	—
Humanities and Engineering or Science[5]	—	—	—	—	—	—	—	—	—	49	412	59	520	40	36	40	87	59
Political Science[9]	—	—	—	—	—	—	—	—	—	—	114	19	133	22	26	23	27	19
Total	—	—	—	—	—	—	—	—	61	201	755	99	1,116	78	93	102	142	99
Alfred P. Sloan School of Management[6]																		
Business and Engineering Administration	—	—	—	—	—	142	872	641	909	732	—	—	3,296	—	—	—	—	—
Management[10]	—	—	—	—	—	—	—	—	—	172	565	66	803	56	49	55	76	66
Total	—	—	—	—	—	142	872	641	909	904	565	66	4,099	56	49	55	76	66
School of Science																		
Biology[7]	—	3	11	25	27	49	57	129	74	116	16	—	507	—	—	—	—	—
Undesignated	—	—	—	—	—	—	—	—	—	—	—	12	12	—	—	—	—	12
Chemistry	2	27	80	154	151	111	141	166	232	207	307	36	1,614	39	34	36	25	36
Earth and Planetary Sciences[8]	—	—	—	8	6	3	36	22	32	141	109	16	373	13	15	15	8	16
Undesignated	—	—	—	—	—	—	—	—	—	—	7	16	23	—	—	1	6	16
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	—	—	—	—	—
Life Sciences[7]	—	—	—	—	—	—	—	—	—	—	291	45	336	36	45	42	46	45
Mathematics	—	—	—	—	—	—	19	48	72	220	831	74	1,264	112	88	68	94	74
Meteorology	—	—	—	—	—	—	—	—	56	38	—	—	94	—	—	—	—	—
Physics	—	5	6	24	19	21	49	170	306	617	1,079	116	2,412	121	106	91	85	116
Total	4	46	114	260	223	210	319	608	865	1,463	2,651	315	7,078	321	288	253	264	315
Grand Total	29	226	507	1,579	2,257	2,963	5,410	4,515	6,626	7,535	8,011	874	40,532	867	761	795	865	874

* 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) of Physics
[4] Prior to 1938 these degrees were included in Mining Engineering and Metallurgy; changed from Metallurgy to Metallurgy and Materials Science, January 1968
[5] Prior to 1958 these degrees were included in General Engineering and General Science or General Course
[6] Changed to Alfred P. Sloan School of Management after 1963
[7] Changed to Life Sciences beginning January 1962
[8] Changed from Geology and Geophysics to Earth Sciences in February 1961. Changed from Earth Sciences to Earth and Planetary Sciences in February 1970
[9] Prior to September 1965, these degrees were included in Economics, Politics and Engineering or Science
[10] Prior to 1959, Business and Engineering Administration, changed from Industrial Management to Management in February, 1967

Table X. Number of Degrees of Master of Science Awarded

	Total by decades											Calendar year since 1967 (included in decade total)				
	1886–90	1891–1900	1901–10	1911–20	1921–30	1931–40	1941–50	1951–60	1961–70	1971–	Grand Total	1967	1968	1969	1970	1971*
School of Architecture and Planning[1]																
Architecture	—	8	45	31	—	—	—	—	—	—	84	—	—	—	—	—
Architectural Engineering[2]	—	—	—	—	9	10	—	—	—	—	19	—	—	—	—	—
Total	—	**8**	**45**	**31**	**9**	**10**	—	—	—	—	**103**	—	—	—	—	—
School of Engineering																
Aeronautical Engineering	—	—	—	17	59	76	307	312	—	—	771	—	—	—	—	—
Aeronautics and Astronautics	—	—	—	—	—	—	—	63	645	35	743	73	63	32	71	35
Building Engineering and Construction	—	—	—	—	—	—	21	66	21	—	108	—	—	—	—	—
Ceramics	—	—	—	—	—	3	3	13	20	2	42	—	2	2	2	2
Chemical Engineering	—	3	2	18	69	152	275	467	398	24	1,408	40	46	28	26	24
Chemical Engineering Practice	—	—	—	—	245	284	241	256	102	18	1,146	14	10	7	13	18
Civil Engineering	—	1	4	27	53	179	194	350	560	36	1,392	59	67	44	46	36
Electrical Engineering (including VI-A)	—	—	7	43	462	474	546	1,164	1,530	71	4,255	163	164	137	138	71
Electrochemical Engineering	—	—	—	4	16	8	—	—	—	—	28	—	—	—	—	—
Fuel and Gas Engineering	—	—	—	—	15	11	—	—	—	—	26	—	—	—	—	—
Mechanical Engineering	—	1	8	22	100	176	388	559	710	62	2,066	65	75	75	73	62
Metallurgy	—	—	—	—	8	36	92	230	205	14	585	12	11	9	10	14
Mining Engineering	—	—	—	9	8	16	—	—	—	—	33	—	—	—	—	—
Naval Architecture and Marine Engineering	—	—	2	1	5	20	60	169	271	23	569	31	29	31	32	23
Naval Construction	—	—	—	5	—	—	—	—	—	—	5	—	—	—	—	—
Naval Construction and Engineering	—	—	39	43	101	89	206	—	—	—	478	—	—	—	—	—
Nuclear Engineering[3]	—	—	—	—	—	—	—	67	282	15	364	27	25	31	37	15
Petroleum Engineering	—	—	—	—	—	5	—	—	—	—	5	—	—	—	—	—
Railroad Engineering	—	—	—	—	—	14	—	—	—	—	14	—	—	—	—	—
Sanitary Engineering	—	—	2	8	3	10	53	99	16	—	191	—	—	—	—	—
Total	—	**5**	**64**	**197**	**1,144**	**1,553**	**2,386**	**3,815**	**4,776**	**300**	**14,240**	**484**	**492**	**396**	**448**	**300**
School of Humanities and Social Science																
Economics[5]	—	—	—	—	—	—	—	—	19	1	20	2	4	6	4	1
Economics, Politics and Engineering or Science	—	—	—	—	—	12	16	19	10	—	57[11]	—	—	—	—	—
Linguistics	—	—	—	—	—	—	—	—	1	1	2	1	—	—	—	1
Philosophy	—	—	—	—	—	—	—	—	2	—	2	—	—	—	2	—
Political Science[6]	—	—	—	—	—	—	—	—	25	4	29	4	3	6	9	4
Psychology[4]	—	—	—	—	—	—	—	—	7	—	7	1	—	—	1	—
Total	—	—	—	—	—	**12**	**16**	**19**	**64**	**6**	**117**	**8**	**7**	**12**	**16**	**6**

Alfred P. Sloan School of Management[5]																
Management[9]	—	—	—	—	4	60	122	581	1,274	154	2,195	132	128	131	159	154
School of Science																
Biology	—	1	1	10	1	19	25	34	21	4	116	1	1	4	4	4
Chemistry	2	3	7	22	32	51	53	46	97	6	314	9	12	8	11	6
Earth and Planetary Sciences[10]	—	—	—	—	—	—	—	—	7	3	10	—	—	—	7	3
General Science	—	1	—	—	—	—	—	—	—	—	1	—	—	—	—	—
Geology and Geophysics[10]	—	—	2	5	21	15	17	48	71	—	179	7	13	9	—	—
Mathematics	—	—	—	2	9	25	45	96	73	5	255	4	10	10	12	5
Meteorology[7]	—	—	—	—	—	35	99	118	87	4	343	10	6	5	6	4
Nutritional Biochemistry and Metabolism[6]	—	—	—	—	—	—	12	51	124	4	190	19	19	17	10	4
Oceanography	—	—	—	—	—	—	—	—	28	4	32	3	5	2	1	4
Physics	—	3	2	2	16	40	50	121	138	19	391	11	6	18	22	19
Total	2	8	12	41	79	185	301	514	647	49	1,838	64	72	73	73	49
Operations Research	—	—	—	—	—	—	—	—	—	7	7	—	—	—	—	7
Without Course Specification	—	—	—	5	308	262	123	357	300	30	1,386	19	29	48	44	30
Grand Total	2	21	121	274	1,544	2,083	2,948	5,286	7,061	546	19,886	707	728	660	740	546

* Includes only February & June degrees
[1] See also Table XI
[2] Prior to 1923 degrees were awarded in Architecture
[3] Prior to 1959 included in Chemical Engineering
[4] Prior to September 1964 included in Economics, Politics and Engineering or Science
[5] Considered Engineering until 1950
[6] Changed from Food Technology and Biochemical Engineering to Nutrition & Food Science in 1962 and to Nutritional Biochemistry & Metabolism June 1967
[7] Considered Engineering until 1956
[8] Prior to September 1965 these degrees were included in Economics, Politics and Engineering or Science
[9] Prior to February 1967, Industrial Management
[10] Changed to Earth & Planetary Sciences beginning February 1970
[11] Includes 6 degrees in Political Science awarded 1965

Table XI. Number of Degrees of Bachelor and Master in Architecture and Bachelor and Master in City Planning Awarded

	Total by decades							Calendar year since 1967 (included in decade total)				
	1921–30	1931–40	1941–50	1951–60	1961–70	1971–	**Grand Total**	1967	1968	1969	1970	1971*
Bachelor in Architecture	—	146	126	257	211	17	**757**	17	24	20	16	17
Bachelor in City Planning**	—	14	13	4	—	—	**31**	—	—	—	—	—
Master in Architecture	63	81	78	191	214	17	**644**	35	30	5	13	17
Master in City Planning	—	18	82	114	152	15	**381**	24	16	12	20	15
Grand Total	**63**	**259**	**299**	**566**	**577**	**49**	**1,813**	**76**	**70**	**37**	**49**	**49**

* Includes only February and June degrees
** From 1935 to 1944, Bachelor of Architecture in City Planning

Table XII. Number of Degrees of Engineer Awarded

	Total by decades				Calendar year since 1967 (included in decade total)				
	1949–60	1961–70	1971–	**Grand Total**	1967	1968	1969	1970	1971*
Engineer in Aeronautics and Astronautics[1]	35	58	4	**97**	6	6	6	3	4
Building Engineer[3]	5	2	—	**7**	—	—	—	—	—
Chemical Engineer	17	31	5	**53**	6	3	2	2	5
Civil Engineer	21	78	7	**106**	13	9	12	6	7
Electrical Engineer	132	444	43	**619**	70	51	61	57	43
Marine Mechanical Engineer	7	2	—	**9**	—	—	—	—	—
Materials Engineer	—	7	—	**7**	—	—	—	—	—
Mechanical Engineer	102	166	13	**281**	13	14	16	17	13
Metallurgical Engineer	24	18	1	**43**	2	3	1	—	1
Meteorologist[2]	2	—	—	**2**	—	—	—	—	—
Naval Architect	11	21	2	**34**	3	6	2	2	2
Naval Engineer	334	246	19	**599**	17	26	27	27	19
Nuclear Engineer	—	37	1	**38**	10	3	9	3	1
Ocean Engineer	—	4	2	**6**	—	—	—	4	2
Sanitary Engineer[3]	9	3	—	**12**	—	—	—	—	—
Grand Total	**699**	**1,117**	**97**	**1,913**	**142**	**121**	**136**	**121**	**97**

* Includes only February and June degrees
[1] Prior to 1960 Aeronautical Engineer
[2] Degree discontinued after July 1955
[3] Degree discontinued after 1964

Table XIII. Number of Degrees of Doctor of Philosophy Awarded

	Total by decades									Calendar year since 1967 (included in decade total)				
	1907–10	1911–20	1921–30	1931–40	1941–50	1951–60	1961–70	1971–	**Grand Total**	1967	1968	1969	1970	1971*
School of Architecture and Planning														
Urban Studies and Planning[6]	—	—	—	—	—	—	24	2	**24**	4	1	8	4	2
Total	**—**	**—**	**—**	**—**	**—**	**—**	**24**	**2**	**24**	**4**	**1**	**8**	**4**	**2**
School of Engineering														
Aeronautics and Astronautics[7]	—	—	—	—	—	6	57	8	**71**	5	10	7	11	8
Chemical Engineering	—	—	—	—	—	—	31	5	**36**	3	2	4	5	5
Civil Engineering	—	—	—	—	—	1	72	11	**84**	6	13	12	25	11
Electrical Engineering	—	—	—	—	1	9	248	33	**291**	32	31	38	39	33
Mechanical Engineering	—	—	—	—	—	4	95	16	**115**	13	13	16	11	16
Metallurgy and Materials Science[3]	—	—	—	—	—	6	103	15	**124**	7	14	28	16	15
Naval Architecture and Marine Engineering	—	—	—	—	—	—	15	3	**18**	—	3	1	6	3
Nuclear Engineering	—	—	—	—	—	5	90	4	**99**	8	12	11	11	4
Sanitary Engineering	—	—	—	—	—	2	3	—	**5**	—	—	—	—	—
Total	**—**	**—**	**—**	**—**	**1**	**33**	**714**	**95**	**843**	**74**	**98**	**117**	**124**	**95**
School of Humanities and Social Science														
Economics[1]	—	—	—	—	19	96	195	6	**316**	26	20	23	29	6
Group Psychology	—	—	—	—	8	1	—	—	**9**	—	—	—	—	—
Linguistics	—	—	—	—	—	—	35	2	**37**	4	4	6	7	2
Philosophy	—	—	—	—	—	—	8	—	**8**	—	—	2	2	—

Political Science	—	—	—	—	—	—	71	6	77	12	12	10	11	6
Psychology	—	—	—	—	—	3†	24	2	29	4	2	5	7	2
Total	**—**	**—**	**—**	**—**	**27**	**100**	**333**	**16**	**476**	**46**	**38**	**46**	**56**	**16**
Alfred P. Sloan School of Management														
Management[2]	—	—	—	—	—	—	89	8	97	15	13	21	13	8
School of Science														
Biology	—	1	10	17	21	38	105	7	**199**	15	12	19	11	7
Chemistry	7	19	59	146	180	342	427	36	**1,216**	41	40	60	50	36
Earth and Planetary Sciences[4]	1	7	10	22	20	71	84	5	**220**	8	7	10	9	5
Mathematics	—	—	6	25	35	70	211	15	**362**	15	24	18	27	15
Meteorology	—	—	—	—	—	14	45	6	**65**	2	4	10	9	6
Nutrition and Food Science	—	—	—	—	4	28	66	6	**104**	9	12	7	11	6
Oceanography[6]	—	—	—	—	—	—	11	—	**11**	2	—	—	—	—
Physics	—	2	6	48	159	283	390	26	**914**	46	38	46	48	26
Total	**8**	**29**	**91**	**258**	**419**	**846**	**1,339**	**101**	**3,091**	**138**	**137**	**170**	**165**	**101**
Awarded jointly with Woods Hole Oceanographic Institute														
Earth and Planetary Sciences	—	—	—	—	—	—	4	—	**4**	—	—	1	3	—
Meteorology	—	—	—	—	—	—	1	1	**2**	—	—	—	1	1
Grand Total	**8**	**29**	**91**	**258**	**447**	**979**	**2,504**	**223**	**4,539**	**277**	**290**	**363**	**366**	**223**

* Includes only February and June degrees
† Previously included in Industrial Economics
[1] Changed from Industrial Economics to Economics 1966
[2] Changed from Industrial Management to Management February 1967
[3] Includes Ceramics
[4] Changed from Geology and Geophysics to Earth and Planetary Sciences 1970
[5] Beginning 1967-68 included in Earth and Planetary Sciences or Meteorology
[6] Changed from City and Regional Planning to Urban Studies and Planning September 1969
[7] Prior to 1960 Aeronautical Engineering

Table XIV. Number of Degrees of Doctor of Science Awarded

	Total by decades								Calendar year since 1967 (included in decade total)				
	1911–20	1921–30	1931–40	1941–50	1951–60	1961–70	1971–	**Grand Total**	1967	1968	1969	1970	1971*
School of Engineering													
Aeronautics and Astronautics[1]	2	4	5	18	31	76	5	**141**	16	9	5	9	5
Chemical Engineering	—	23	78	114	117	151	8	**491**	13	7	12	13	8
Civil Engineering	—	2	12	23	46	75	7	**165**	4	6	4	7	7
Electrical Engineering	3	12	30	34	141	124	4	**348**	5	8	4	9	4
Electrochemical Engineering	—	1	1	—	—	—	—	**2**	—	—	—	—	—
Mechanical Engineering	—	4	13	35	125	145	8	**330**	23	15	21	4	8
Metallurgy and Materials Science[2]	—	14	32	86	194	201	6	**533**	25	11	12	10	6
Mineral Engineering	1	—	4	—	—	—	—	**5**	—	—	—	—	—
Naval Architecture and Marine Engineering	—	1	—	—	2	6	1	**10**	—	—	1	—	1
Nuclear Engineering	—	—	—	—	9	55	2	**66**	7	3	5	10	2
Petroleum Engineering	—	—	1	—	—	—	—	**1**	—	—	—	—	—
Sanitary Engineering	—	—	2	3	18	2	—	**25**	—	—	—	—	—
Total	**6**	**61**	**178**	**313**	**683**	**835**	**41**	**2,117**	**93**	**59**	**64**	**62**	**41**
School of Science													
Biology	—	—	—	—	—	1	—	**1**	—	—	1	—	—
Chemistry	—	2	5	4	3	1	1	**16**	—	—	—	1	1
Earth and Planetary Sciences[3]	1	2	4	5	2	3	—	**17**	—	—	—	2	—
Mathematics	—	2	3	—	1	1	1	**8**	—	—	—	—	1
Meteorology	—	—	6	25	17	6	—	**54**	1	1	—	3	—
Nutrition and Food Science	—	—	—	3	10	17	3	**33**	4	2	2	2	3
Oceanography[4]	—	—	—	—	—	1	—	**1**	—	—	—	—	—
Physics	—	5	18	14	7	6	1	**51**	1	—	—	—	1
Total	**1**	**11**	**36**	**51**	**40**	**36**	**6**	**181**	**6**	**3**	**3**	**8**	**6**
Awarded Jointly with Woods Hole Oceanographic Institute													
Meteorology	—	—	—	—	—	—	1	**1**	—	—	—	—	1
Grand Total	**7**	**72**	**214**	**364**	**723**	**871**	**48**	**2,299**	**99**	**62**	**67**	**70**	**48**

* Includes only February and June Degrees
[1] Prior to 1960 Aeronautical Engineering
[2] Including Ceramics
[3] Changed from Geology and Geophysics to Earth and Planetary Sciences 1970
[4] Beginning 1967-68 included in Earth and Planetary Sciences or Meteorology

Table XV. Summary of Degrees Awarded (1868-1971)

Bachelor of Science	40,532
Bachelor in Architecture	757
Bachelor in City Planning (discontinued after 1954)*	31
Master of Science	19,886
Master in Architecture	644
Master in City Planning	381
Master in Public Health (discontinued after 1944)*	104
Advanced Engineering	1,913
Doctor of Philosophy	4,533
Doctor of Philosophy awarded jointly with Woods Hole Oceanographic Institute	6
Doctor of Science	2,298
Doctor of Science awarded jointly with Woods Hole Oceanographic Institute	1
Doctor of Public Health (discontinued after 1944)*	9
Doctor of Engineering (discontinued after 1918)*	4
Grand Total	**71,099**

* See the 1959 Report of the Registrar for details.

WARREN D. WELLS

VICE PRESIDENT AND SECRETARY OF THE INSTITUTE

The Corporation and the Committees of the Corporation, the Institute's relations with industry, and the ongoing program to develop private support for M.I.T. constitute the assignment of the Vice President and Secretary of the Institute. The past year brought important changes in all of these areas, including several instances of record growth and activity. For example, the $39.6 million total of gifts, grants, and bequests received during the year represented a five-year record and the second highest total for any year since the founding of the Institute.

The directors of the Industrial Liaison Office, M.I.T. Associates Office, Registry of Guests, and Development Office and the Manager of Endicott House have submitted reports to the President which are part of the formal record of the Institute. This report summarizes their work and the progress of the Institute Secretaries, who also report to the President through the Vice President and Secretary of the Institute. Additional responsibilities assumed by the Vice President and Secretary during the past year included the chairmanship of the Endicott House Board of Governors.

CORPORATION MEMBERSHIP

The election of President Howard W. Johnson on September 9, 1970, as Fifth Chairman of the Corporation to succeed Dr. Killian on July 1, 1971, and the March 5, 1971, election of Provost Jerome B. Wiesner as the thirteenth President of the Institute and Dean Paul E. Gray as Chancellor of the Institute, effective July 1, 1971, were the high points of a busy and productive year for the Corporation. The further election on June 4, 1971, of Dr. Killian as a Life Member of

the Corporation and as Honorary Chairman, following Dr. Bush's announcement of his desire to relinquish this designation in order that an additional honor might be conferred upon Dr. Killian, were among the important changes occurring in Corporation membership during the year.

At the year's end there were 85 Members of the Corporation — 70 Active Members, 10 Life Members Emeriti, and 5 Members-Elect of the Corporation due to assume office at the October 8, 1971, Meeting of the Corporation as Representatives from Recent Classes. During the year the Corporation gained through election at the October 2, 1970, Annual Meeting the membership of Dr. Ralph M. Davison '66 — at the time of his election, at age 26, the youngest Corporation Member ever to be elected — and Whitney M. Young, Jr., Executive Director of the National Urban League. Mr. Young's untimely death on March 11, 1971, shocked and grieved the nation. A student at M.I.T. during World War II and a member of the Visiting Committee of the Joint Center for Urban Studies for several years, he was the second black American to be elected to the Corporation.

The Corporation further lost through death on October 14, 1970, Life Member Emeritus and Honorary Secretary, Walter Humphreys, and on March 18, 1971, its Life Member Emeritus, Mervin J. Kelly, former President of Bell Telephone Laboratories.

The Honorable G. Joseph Tauro succeeded The Honorable Raymond S. Wilkins as Chief Justice of the Supreme Judicial Court of the Commonwealth of Massachusetts following the latter's retirement on September 1, 1970. In this capacity he also succeeded Chief Justice Wilkins as a Representative of the Commonwealth on the M.I.T. Corporation. The Corporation was saddened to learn a short time later of the death of Judge Wilkins, who has served as an *ex officio* Member of the Corporation from 1956-1970.

The Corporation elected Dr. George W. Thorn, Physician-in-Chief of the Peter Bent Brigham Hospital to a continuing five-year term at the June 4 Meeting of the Corporation. Also elected to five-year terms were: Paul M. Cook '47, President, Raychem Corporation; William S. Edgerly '49, Financial Vice President and Director, Cabot Corporation; and Kenneth H. Olsen '50, President, Digital Equipment Corporation. Paul V. Keyser '29, will continue as *ex officio* Member of the Corporation by virtue of his reelection as the 1971-72 President of the Alumni Association — the first person in decades to serve two terms in that position. In electing Dean Paul E. Gray as Chancellor of the Institute, effective July 1, 1971, the Corporation also elected him as an *ex officio* Member of the Corporation and of its Executive Committee.

Expiration of term membership cost the Corporation the formal services of J. Kenneth Jamieson '31, Chairman, Standard Oil Company (New Jersey); John Lawrence '32, Chairman, Dresser Industries; George R. Vila, '33, Chairman and President, Uniroyal, Inc.; and Robert B. Woodward, '36, Donner Professor of Science, Harvard University. These retiring Corporation Members continue their association with the Corporation in important ways as members of various Corporation Committees.

As a matter of record, the Corporation held five meetings during the year, including a special meeting on September 9, 1970. In a year when the selection of new leadership for M.I.T. demanded an extra effort by all segments of the Institute community, the Corporation played a central role in communicating with students, faculty, alumni and general public on the range of questions and issues before M.I.T. Special thanks are due the Faculty Advisory Committee, under the chairmanship of Professor Patrick M. Hurley, and C.J.A.C., under the chairmanship of Gregory Smith, for their invaluable assistance to the Corporation Committee on the Presidency, chaired by Dr. James B. Fisk, in the matter of presidential succession at M.I.T. Walter L. Milne served as administrative aide to the Corporation Committee on the Presidency. Mr. Milne also provided staff support to the Corporation in the deliberations on proxy matters.

REPRESENTATIVES FROM RECENT CLASSES

Among the important votes and decisions taken by the Corporation were those relating to the establishment of a new category of alumni membership entitled Representatives from Recent Classes. This development is part of a continuing effort beginning in the mid-sixties to diversify the composition of the Corporation, which resulted in significant changes in the Bylaws relating to membership in 1968. At its March 5, 1971, Meeting the Corporation brought to a conclusion several years of study and discussion among several committees of the Corporation, including the Executive and Membership Committees and C.J.A.C., in voting to amend the Bylaws further to add a new group of younger alumni to the Corporation. Under a detailed procedure described in the amended Bylaws, an election among the senior class, terminal year graduate students, and graduates in the last two years was held in the spring of 1971 to nominate five alumni to this new category of membership. Laurence Storch, a senior who received his S.B. degree, became the youngest person at age 21 ever to be elected to the Corporation. He will serve for one year. Others elected at the June 4, 1971, Meeting of the Corporation were Pamela T. Whitman '70,

for five years; Michael V. Sawyer '71, for four years; Christina H. Jansen '63, for three years; and James A. Hester '65 for two years. All of the new Representatives from Recent Classes are scheduled to assume office on October 8, 1971. Special thanks are due the Corporation Screening Committee, under the chairmanship of Breene M. Kerr, the staff of the Alumni Association, Robert D. Blake and Miss Donna C. MacPhee for the herculean effort required to make this new membership category a reality during 1970-71.

CORPORATION JOINT ADVISORY COMMITTEE ON INSTITUTE-WIDE AFFAIRS

This new advisory committee to the Corporation completed its second year of operation under the chairmanship of Gregory Smith '30. The Committee held 17 regular open meetings during the year as well as numerous closed meetings; these included sessions with the Executive Committee, Corporation Committee on the Presidency, Faculty Advisory Committee and others. Special attention was given by C.J.A.C. to the structure of the presidency and to the qualifications desired in candidates for the Office. The work of the student members of C.J.A.C. deserves special mention for the opportunities they developed for students broadly to contribute to the study of the presidency. Other important topics examined by C.J.A.C. included the plans for the development of the Simplex property acquired near M.I.T., the issues involved in the second year of the General Motors proxy dispute, the finances of M.I.T., and the role of a possible ombudsman at the Institute. The writer wishes to acknowledge the remarkable contribution C.J.A.C. has made on these and other questions in building respect and mutual understanding within the M.I.T. community. Particular credit is due the chairman, Gregory Smith, for his lasting service in providing leadership and timely documentation of the work of C.J.A.C. The Committee was greatly assisted in its deliberations by the able staff support of Dr. Walter L. Koltun and his office. The undersigned wishes to express appreciation to Dr. Irving M. London, Director of the Joint Harvard-M.I.T. Program in Health Sciences and Technology for Dr. Koltun's valuable services as Secretary to C.J.A.C.

DEDICATIONS

The Office of the Vice President and Secretary continued to carry prime responsibility for dedications of major facilities. Notable cere-

monies this year included the dedication of the Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics on October 1 and 2, 1970, in conjunction with an international symposium to mark the occasion and the formal opening of Frank S. MacGregor House, an undergraduate residence for 300 students, on November 6, 1970. Vice President Kenneth R. Wadleigh organized the MacGregor House dedication aided by a committee of students and staff. I am happy to acknowledge this fine effort and the memorable occasion which resulted. Mr. MacGregor was unable to be here for the dedication but came some months later for the unveiling of his portrait at MacGregor House. At the year's end the George R. Wallace, Jr. Astrophysical Observatory was completed and due to be officially opened in the fall of 1971 at a site near the Haystack Radar Facility of Lincoln Laboratory in Westford, Massachusetts. Ceremonies to commemorate the establishment of the Robert R. Shrock Professorship in Earth and Planetary Sciences, a gift of Mr. and Mrs. Cecil H. Green, the Frederick George Keyes Professorship of Chemistry, the fiftieth anniversary of the founding of the Department of Chemical Engineering, and a number of other departmental functions were planned and executed with assistance from the Office of the Vice President and Secretary.

The Corporation and Former Members of the Corporation also met on the evening of June 3, 1971, to honor Dr. and Mrs. Killian at a formal reception and dinner at the President's House and Morss Hall in Walker Memorial. The dinner at which President Johnson presided was attended by 126 guests. John J. Wilson, dinner chairman, presented Dr. and Mrs. Killian with an inscribed silver tray as a memento of the occasion marking his retirement as Chairman of the Corporation. Dr. Vannevar Bush, President-elect Jerome B. Wiesner, Cecil H. Green, and David A. Shepard spoke at the dinner.

CORPORATION VISITING COMMITTEES

The expansion in size of each Visiting Committee was continued in 1970-71, looking towards an ultimate composition of three Corporation nominees, six Presidential nominees, and six Alumni nominees, or fifteen-member Committees in place of the present nine-member Committees. The rationale for this move is to strengthen the Visiting Committees, recognize the growing numbers of distinguished alumni who are eligible and anxious to serve on these Committees, and to support greater attendance at mid-winter meetings of Visiting Com-

mittees. I wish to acknowledge the long standing recommendation of our Life Member, Senator Thomas C. Desmond, that these Committees be enlarged.

In 1970-71, 243 individuals served on one or more of the 26 Visiting Committees. They included 56 Members of the Corporation, 114 Members nominated by the President, and 73 Members nominated by the Alumni Association. The outlook for 1971-72 is for the completion of additional recruitment of Visiting Committee Members to provide a total of some 350-375 advisors serving the Institute in these key Committees.

During the year, 19 Visiting Committees held meetings, including the Visiting Committee for the Harvard-M.I.T. Joint Center for Urban Studies. Three Visiting Committees met twice during the year on behalf of Chemical Engineering, Student Affairs, and the Joint Center. Although the number of Committees which met was at or near the optimum number, too many of the meetings were bunched once again in the spring of the year, with a resulting crush on the calendar. Three fourths of the meetings were held after the turn of the new year. With the earlier fall term start in September and the Independent Activities Period in January, we are endeavoring to place as many of these meetings as possible in the fall term of the 1971-72 year. There are inherent problems in doing this. The Visiting Committees are not officially constituted until October of each year, and the fall is not as popular as the spring with the Committee chairmen and with department heads as a general period for meeting. In addition, summer meetings are generally not practical from a scheduling point of view.

David J. Tobin provided administrative support to the Visiting Committee program, including the scheduling and arranging of meetings, sending pertinent reports and press notices to the Committees during the year, processing the written reports of Committee meetings and in general, providing a base for effective communication with the individual Visiting Committee Members. Thanks are due once again to Dr. Jerome B. Wiesner and to the Nominating Committee of the Alumni Association for their help in the selection of nominees to these important Committees of the Corporation. Dr. Walter A. Rosenblith was an active participant in Visiting Committee meetings, along with the deans, and he was a principal representative of the President and Provost in meetings they could not attend. The writer also wishes to acknowledge and thank the department chairmen for their excellent preparation for Visiting Committee meetings and the enthusiastic participation of well over 300 faculty members in these sessions.

The inclusion of student meetings, presentations, and discussions in

the regular agenda of these Visiting Committee meetings was a major factor in the success of the Visiting Committee operation this year. The Committee chairmen made a concerted effort across the board to include extensive contact with students in each of the departments and areas being visited. In the case of the Department of Physics, two student presentations to the Visiting Committee were later repeated at the March 5, 1971, Meeting of the Corporation. It is the Institute's good fortune to have this system of advisory committees in existence during a period when students have sought a greater voice in the governance of the Institute and when opportunities for student-trustee interaction are a priceless asset in the process of change. Within the context of departmental and professional concerns, our students have brought invaluable experience and perspectives to bear on the deliberations of the Visiting Committees.

In two significant actions, the Corporation voted to establish a separate Department of Philosophy, and it moved to create a Corporation Visiting Committee for the Arts at M.I.T., including music, drama, film, photography, and the arts of painting and sculpture. These two actions increase the number of Corporation Visiting Committees from 26 to 28 for the coming year.

DEVELOPMENT

As reported earlier, the cash total of nearly $40 million received in gifts, grants, and bequests was the second best year for private support since the founding of the Institute. It brought the five-year total received during President Johnson's administration to just over $132 million or $26.5 million per year on the average. The comparable figures for the preceding five years were $122 million and $24.4 million respectively. Considering the paralyzing effect on private philanthropy of the Tax Reform Act of 1969, the lacklustre performance of the economy since 1968, the drain of campus unrest on the time available for solicitation by senior officers, and the absence of a highly publicized capital campaign, the five-year comparison is more favorable than it would appear at first glance. The more than $256 million given to M.I.T. during the past decade represents about 70 per cent of the total gifts, grants and bequests received since the founding of the Institute 110 years ago.

The past year was characterized by a worsening of the financial plight of the private colleges and universities. Nationally, a steady stream of studies all carried universal warnings of the deepening depression in

higher education. No one has stated the failure of the nation to heed these warnings more succintly than President Alan Pifer of the Carnegie Corporation of New York in the Foundation's 1970 Annual Report. Speaking of the jeopardy of private institutions, he wrote:

> Private nonprofit institutions serving the public good are one of those special features of American life so much taken for granted they have long since become obscured in a haze of familiarity. And yet, if one has occasion to observe life in a nation where all activities are functions either of the state or of a single, authorized political party, the value of independent private institutions, to our perception of a good society, becomes freshly and arrestingly apparent.
>
> Nevertheless, a high proportion of our private educational cultural, health, and welfare institutions are heading into deep trouble, increasingly affected by social and economic forces they are powerless to withstand. The steady, unrelenting deterioration of their position has now, for the first time, raised doubts about the continued viability of our traditional system of shared responsibility between public and private endeavor. For varying reasons, the American people at large and most of their political leaders seem either unaware of the situation, or unconcerned. In an age notable for the gravity and complexity of its problems, this problem, as important as many others with which we are currently obsessed, has simply failed to make its mark on the national consciousness.

The sporadic closings of marginal colleges and the publicity given the discontinuance of schools and departments in some universities mask the more important corrosive effects of the new depression in higher education.

Though better off than most of its peer group of institutions, M.I.T. is confronted with the same problem of expenses growing at a rate faster than the growth in revenues from all sources.

The heavy drain of unrestricted gifts to meet the Institute's 1970-71 operating shortfall and the further resort to unrestricted gifts for operating purposes in 1971-72, instead of for capital improvements as in the past, represents a new mode of finance for M.I.T. It places a premium on continuing expense control and upon the generation of major, additional unrestricted funds to help meet the budget. M.I.T.'s strained finances are threatened further by prospective losses of operating revenue to the general account from the separation of the Charles Stark Draper Laboratory from the Institute. The urgency of this aspect of M.I.T.'s finances is such that a number of capital projects have had to be deferred in favor of concentrating on the core needs of the Institute.

These included during 1970-71 a determined effort to identify new sources of support to increase the Institute's unrestricted resources, student aid, faculty endowment, and the completion of four building projects to which the Institute was already committed and for which partial funding had already been secured, the Electrical Engineering and

Electronics Complex, renovation of Sancta Maria Hospital building, renovation of Buildings 4 and 6 of the Department of Chemistry, and the private portion of the funding for Westgate II.

The Corporation Development Committee once again provided leadership in the acquisition of capital resources. The Committee held its annual meeting in Cambridge on November 6, 1970; two additional meetings of regional members were held in Los Angeles and Dallas during the year. Members were asked on an individual basis to take the responsibility for assisting M.I.T. to secure a minimum of $100,000 in new funds, as part of the problem of dealing with uncompleted capital projects and the need for additional unrestricted funds. The results were most gratifying, with scores of Committee members contributing ideas, information, and in many cases personal introductions and gifts to meet the Institute's request. This important, new phase of Committee work is continuing.

The addition of new members to the Development Committee maintained its strength at 140, including 22 Members of the Corporation and 118 alumni serving for three-year terms. There are 8 new alumni members and the *ex officio* membership is increased by two positions. Thanks are due Donald P. Severance and Kenneth S. Brock of the Alumni Association and Nelson C. Lees of the Development Office for their assistance in maintaining the quality and strength of this key Committee.

In a significant amendment of the Bylaws, the Corporation voted to make it possible for any Member of the Corporation to serve as chairman of the Development Committee by annual election. Previously, the Chairman of the Corporation served as chairman *ex officio* of the Development Committee.

Dr. James R. Killian, Jr. was elected chairman of the Development Committee for 1971-72 in what was undoubtedly the most important single event affecting the future course of the Institute's development. The statistics of the Institute's gift stream during the past decade speak to this point.

The large total of gifts, grants, and bequests received during 1970-71 eclipsed a number of equally encouraging achievements which should be noted.

There was a net addition of 26 living individuals whose personal donations and new pledges brought the total of living donors who have given M.I.T. $25,000 or more during their lifetime to 210 living individuals. As a matter of interest, these 210 individuals have now given or pledged a total of $45 million to M.I.T. during their lifetimes. Interestingly, one-third of these major donors are Members of the Corporation or of its Standing Committee on Development; one-fourth are not

alumni of the Institute; and 30 of them are present or former members of the Faculty or staff of the Institute.

Gifts by living individuals, though down slightly to $5.3 million from last year's record total of $5.7 million, continued to grow significantly in the middle and lower ranges of giving. Gifts by individuals continue to represent M.I.T.'s great hope for increased total private support for the future. In addition, the number of living donors reached a new all time high for a single year. The donor count was helped by the continued steady increase of Alumni Fund donors to a record 21,000, an impressive increase of nearly 1,000 donors to the Fund. M.I.T.'s Alumni Fund experience was also up about 10 per cent in dollars and compared favorably with the leading annual funds of sister institutions, several of whom lost donors as well as dollars during a generally trying period for the country's collegiate annual funds.

The number of plans for estate gifts on record with the Institute Estate Secretary has increased by a net of 17 persons, after a careful review of existing donor intentions. A record total of 705 individuals, both alumni and friends, have now notified the Institute of their plans on a confidential basis. This total includes 42 life income trusts held by M.I.T. and 26 estates in process.

Gifts and grants by foundations and charitable trusts made a strong comeback this past year. Ninety-nine foundations and 16 charitable trusts made gifts and grants totalling $6.5 million. Included were 25 foundations and 2 charitable trusts which made gifts and grants to M.I.T. for the first time. These first time donors accounted for a record $1.5 million of the total foundation revenue received during the year. Gifts and grants from foundations other than the Ford Foundation and Sloan Foundation also showed an encouraging increase for the fifth consecutive year. Their dollar total has doubled in the past three years. Whereas Ford and Sloan represented roughly 75 per cent of M.I.T.'s foundation income in earlier years, the greater growth of other foundation sources has reduced the Ford and Sloan fraction of total foundation giving to M.I.T. to around 40 per cent of the total.

The Institute's ability to attract foundation support from a broader base of philanthropic institutions reflects a partial shift from Federal to private research funding by many campus research programs, a broader scope of research and teaching at M.I.T., and a persistent effort by the Institute Secretary for Foundations and the Institute Secretary for Charitable Trusts to develop greater effectiveness in M.I.T. appeals to foundation sponsors.

The leverage value of modest support from private foundations continues to be greatly underestimated. For example, support from smaller

foundations and charitable trusts secured by the Institute Secretaries was instrumental in securing major Federal support for one laboratory.

The full effects upon foundations from the Tax Reform Act of 1969 are only beginning to be seen. There does not appear to be a wholesale movement to abandon existing private foundations as had earlier been feared, although there have been isolated cases of foundations electing to discontinue operations.

Corporate gifts and grants continued their remarkable upward climb despite the problem of depressed corporate earnings. With the exception of grant payments from one major corporate donor, industrial support reached a five year high of $5.9 million. This represented more than one fourth of M.I.T.'s gift income from living sources and served to emphasize once again the Institute's very great dependence upon support from American industry. M.I.T. relies for a substantially greater fraction of its total gift income upon corporate sources than do most colleges and universities, according to the national percentages of collegiate gift income contributed by corporate sources.

An important start was made during the year to begin the articulation of venture capital giving as a wholly new source of potential income for M.I.T. A committee of faculty members was convened by Dr. Killian to begin deliberations in this important and extremely sensitive area.

The number of off-campus visits paid to donors and prospective donors by members of the faculty and development staffs, including the visits paid under the Industrial Liaison Program topped 1,000 for the first year.

President Johnson convened a special conference on May 25, 1971, on The Arts at M.I.T., to report the Institute's progress in the Arts to interested alumni and friends and to plan the organization of a nationally-based advisory committee. Some 90 persons participated in this landmark beginning of a new chapter in the development of the arts at M.I.T. Dean Emeritus John E. Burchard and Francis Park III carried the responsibility for planning this conference, with timely assistance from the Development Office. Paul Tishman '24, was named Chairman of the new organization at M.I.T.; Angus N. MacDonald '46, and Mrs. Ida M. Rubin of New York City were named Co-Chairmen.

All in all, it was a notable year for private support of M.I.T. in which the Institute grew in its base of contributors, set several important gift records, made substantial progress in its internal systems supporting development activity, and maintained favor with living donors. The heart of this quiet but far reaching progress for M.I.T. is the Development Office under the direction of Nelson C. Lees, strongly supported by James W. Lambert. Prior to Mr. Lambert's appointment as Assistant

Director in 1970, he served as the development officer for the School of Engineering at the University of Southern California.

The Institute Secretaries, D. Hugh Darden, C. Warren Smalzel, David J. Tobin and Paul H. Burr with Arnold H. Singal assisting Mr. Darden, set new records in developing improved communication with prospective donors among private individuals, corporations, charitable trusts and foundations. These five development officers, working closely with the Development Office, are responsible for the day-to-day performance of a development program that places M.I.T. among the nation's top five private universities receiving private support and with institutions that are larger and older. M.I.T. is exceptionally fortunate to have these senior administrative officers who are committed to keeping the Institute financially strong and free. Their work was bolstered during the year by the part-time services of Vice President Malcolm G. Kispert who began a special effort to attract increased financial support for student aid from alumni and friends of the Institute.

INDUSTRIAL LIAISON PROGRAM

Under the able and experienced leadership of Jack W. Christensen, Director of the Industrial Liaison Office, the Institute continued to set a national example for industry-university cooperation. The changing pattern of Federal support for university research and scholarship has brought renewed significance to M.I.T.'s relationships with private industry. As it has done for more than 22 years, our Industrial Liaison Program provides the principal mechanism for developing and conducting the Institute's long-standing and mutually serving interaction with leading industrial firms.

In spite of national economic factors which have made it difficult to obtain commitments from new firms and have forced a few companies to suspend membership, industrial support of the Liaison Program has remained relatively stable. Participants now number 100, down from 105 last year. Forty-five of the present member companies have been active participants for the past fifteen years; 65 companies have now reached their tenth year. In light of the strong internal pressures upon most organizations to reduce expenditures, this is a remarkable record, reflecting industry's high regard for professional contact and technology transfer with M.I.T.

Participants were offered 15 symposia covering a broad range of topics in engineering, science and management. Attendance totaled 1,030 persons compared to 1,466 last year. This decrease is a direct result of continuing travel restrictions imposed by corporations and

would be more severe except for our having presented a conference in New York and two separate conferences in Los Angeles, meetings addressed to special interests of organizations in those areas. Ninety-three members of M.I.T.'s faculty and staff and 12 speakers from other universities government and industry presented research reports at these symposia.

The 1971 *Directory of Current Research* documented 1,619 current research projects, up from 1,522 in 1970. During the year 4,466 copies of the Directory were distributed and served to stimulate an increasing volume of requests for further information. Another access to M.I.T. research results was provided by distribution of over 34,000 copies of our *Monthly List of Publications.* Seven hundred and forty-three separate titles, up from 509 last year, were automatically distributed or made available. In total the Industrial Liaison Officers and the Industrial Liaison Office Publications Office responded personally to more than 5,500 inquiries from companies during this period. In cooperation with the M.I.T. Libraries, 504 Library Privilege Cards were issued to member companies for their use. This total is down from 709 cards issued the previous year, due to improved monitoring.

Continuing emphasis was placed upon identifying areas of mutual activity and interest between individuals at M.I.T. and at industrial firms, and in working to bring those individuals into personal contact. For this purpose 311 visits to company facilities were made by our Industrial Liaison Officers. In turn 337 company representatives came to M.I.T. for 638 separate conferences with members of the faculty and staff. These generally informal discussions were arranged and attended by the company's assigned Liaison Officer and involved 382 different members of the faculty and staff. In addition, 230 visits, sponsored by the Liaison Office, were made by faculty members to company facilities. Companies are especially enthusiastic to receive faculty and these visits result in continuing communications, and frequently, sponsored research and consulting.

During the year, J. Peter Bartl, Leslie M. Boring, Harry C. Moser, Ronald A. Norelli, Jerome J. Schaufeld and Charles J. Sheehan served as Industrial Liaison Officers. In September Mr. Boring was appointed Director of the M.I.T. Associates Program and James E. Fleischhacker was appointed to the staff as his replacement. During the year Elizabeth L. McLean succeeded Margaret E. Bradley as Administrative Assistant. The initiative and effort of the Liaison Office staff, and the cooperation and interest of the faculty have continued to ensure that the Liaison Program has brought substantial benefits to both M.I.T. and to member companies.

M.I.T. ASSOCIATES PROGRAM

During this past year, the tenth since its founding in 1961, the M.I.T. Associates Program has responded to the economic recession and its challenges for small to medium sized corporations with an increased quality of service based on personal interaction between member firms and the Institute. With the addition of two new member firms in the Midwest, the scope of the Program has grown to include nationally-based firms whose corporate interests include light manufacturing, construction, aerospace, insurance, banking, investment analysis, computer hardware and software, electronic components and systems, utilities, chemicals, pharmaceuticals, educational programs, and management services. At year's end there were 26 participating companies in the Program. During the year 66 faculty and staff members were visited by 41 corporate representatives to discuss areas of mutual interest, and nine faculty members have visited corporate and research offices of member firms. This activity represents a marked increase in the level of personal interaction with member firms over the past years. The Associates Office staff is most appreciative of the excellent cooperation and assistance of the Institute's faculty and staff in providing opportunities for such interaction.

The Associates Office once again carried the responsibility for the Institute's Annual Conference for New England Executives. This year's topic was "New England Industry and Environmental Quality." Invitations were extended to corporate executives in a wide cross section of New England firms and 217 guests attended. A keynote speaker was Dr. Edward E. David, Jr., Special Assistant to the President for Science and Technology and Director of the Office of Science and Technology. This was Dr. David's first appearance in New England since his appointment with the Federal government.

I wish to recognize the outstanding progress of the Associates Program under Leslie M. Boring's direction. In this new post he succeeded David H. Robbins who completed his tour of duty and resigned to accept a position in industry. Mr. Boring has brought extraordinary energy and dynamic leadership to the Associates Program which augurs well for its continued growth and development.

REGISTRY OF GUESTS

The Registry of Guests under the skilled direction of Carolyn B. Cox, logged a total of 1,037 visitors from 74 countries during the year. Again Japan topped the list with 252 short-term visitors.

The number of foreign staff and faculty recorded by the Registry was slightly higher than in preceding years with a total of 436 long-term visitors. Again this year the largest proportion was from England, closely followed by Germany, and in all 58 countries were represented.

Mrs. Cox reports that a considerable amount of Registry time was expended as usual in preparing for Commencement. With the current trend toward more informal inauguration ceremonies, however, there was less need to invite delegates to represent M.I.T. at academic functions at other institutions, but there was still demand for a number of formal Institute Greetings to be prepared by the Registry.

M.I.T. ENDICOTT HOUSE

Capital improvements to M.I.T.'s conference center in Dedham, Massachusetts, a new rate structure authorized by the Endicott House Board of Governors, and a clarification of use policy for the House were among the significant developments during the year.

Under the supervision of its dedicated Manager, Aimee Pierson, Endicott House continued to play a key role in expanding educational opportunities for the departments and laboratories of the Institute. The Alfred P. Sloan School of Management continued as the heaviest user of the House, with two sessions of the Program for Senior Executives and a special Program for Urban Managers. In addition, important new use of the House were developed during the year, including meetings held during the January Independent Activities Period. During the life of the Commission on M.I.T. Education, the Killian Suite at Endicott House served as the off-campus headquarters for Professor Kenneth M. Hoffman, Chairman of the Commission. The December 1970 meeting of the Corporation was held at Endicott House.

Demand for conference facilities declined everywhere as academic budgets reflected new stringent conditions throughout the country. As a conference center, Endicott House experienced a higher than usual rate of cancellation and reduced demand. However, Miss Pierson notes that the House was open for the full 12 months of 1970-71 and used 256 days, including 180 nights by 26 resident conferences. Overnights totalled 3,951, an average of 21.5 guests per night. In addition, 97 non-resident groups, representing a total of 6,258 guests used the House during the year. A total of 18,354 meals were served during the year, an average of 71.5 meals per day of operation. Special thanks are due the staff at Endicott House for their constant attention to service and beauty, which give the House its distinctive qualities.

During the year, Dean Robert A. Alberty and Professor Harry C. Gatos joined the Board of Governors. There is no adequate way to thank Dean Emeritus E. Pennell Brooks, Professor Thomas B. King, and Professor Robert R. Shrock, all of whom completed many years of service on the Board. Philip A. Stoddard, Vice President-Operations, former Chairman of the Board, continued to make important contributions to the House as a Board Member, particularly to the management of its capital improvements. The Board of Governors acknowledge a debt to the staffs of Physical Plant and the Accounting Office for valuable assistance rendered.

During the year Robert D. Blake succeeded Francis Hartley IV, who resigned to return to secondary school teaching. Other personnel changes included the joint appointment of Kendall B. Randolph by the Department of Chemical Engineering and the Vice President and Secretary, to help plan new facilities for the Department, and the appointment of Dr. Walter L. Koltun as Assistant Director for Resources of the Joint Harvard-M.I.T. Health Sciences and Technology Program.

VINCENT A. FULMER

OTHER OFFICES

ALUMNI ASSOCIATION

My annual report last summer recalled that the program of the Alumni Association for 1969-1970 had been dominated by three influences: student activism, many changes on campus, and to a lesser extent, the increasingly adverse national economy. Although this year the campus has been free of the kind of demonstrations and disorder which marked so many campuses including our own in 1969-1970, the employment situation for scientists and engineers and the stagnant economy continued to dampen some of our efforts in spite of the resurgence in the stock market during the winter and spring.

We had expected the report of the Hoffman Commission on the nature and the purpose of an M.I.T. education to be the dominant influence on the Association this year, but that was overshadowed by the process of selecting M.I.T.'s new president. Paul V. Keyser, as President of the Alumni Association, and as a member of the Selection Committee on November 12, 1970, sent a letter to approximately 40,000 alumni inviting their ideas regarding candidates for the presidency and the structure of the Office of the President.

Hundreds of alumni responded to this invitation, and their interest and comments were of substantial help to the Selection Committee. Within 48 hours after the final recommendations of the Selection Committee had been accepted by the Corporation on March 5, a second letter from Mr. Keyser was sent to M.I.T. alumni announcing the election of Dr. Jerome B. Wiesner as President and Professor Paul E. Gray as Chancellor.

ALUMNI FUND

This was another banner year for the Alumni Fund. For the eighth consecutive year the number of donors reached a new high 21,344, up 883 over 1970. The amount of the contributions, $2,564,395, reversed the trend of 1970, being an increase of $263,219 over last year and the second highest (after 1969) in the Fund's history. At a time when all colleges and universities face a bleak financial outlook, these two results — increasing donors and dollars — are welcome and suggest that there may be opportunities for greater expansion of financial support from alumni than from any of M.I.T.'s other philanthropic constituencies. To realize the opportunities will challenge our entire organization.

The Fund programs did not vary significantly from recent years but benefited greatly from having experienced staff in contrast to the rather frequent staff turnover immediately preceding 1969. Thus such programs as telethons and up-grading could be expanded from their earlier base. For example, the 12,000 calls placed to alumni throughout the country in the telethons represented an increase of 50 per cent over the previous year. There was also a further expansion of the geographic program wherein 265 regions were organized, a new record for that program.

The three major reunion classes — 1946, 1931, and 1921 — achieved much more substantial gifts than their immediate predecessors. We can anticipate that the next few reunion classes will be larger and will have developed considerable esprit de corps over the years, two elements that should lead to increasing reunion gifts.

The basic philosophy of Fund operations is the involvement of large numbers of alumni volunteers and, as such, it involves more than any other single alumni activity. Typically, about 2,500 alumni each year serve on committees, as agents or chairmen, and as solicitors.

TECHNOLOGY REVIEW

Technology Review completed its 73rd volume with the July/August 1971 issue, recording continued progress toward its goal of establishing itself as a nationally circulated magazine. Volume 73 contains essentially as many pages as the predecessor Volume 72. Readers have reported enthusiastically about much of the editorial content, and there have been increasing requests for reprints and references in the public press.

However, 1970-71 has been a poor year in magazine publishing, and the *Review* has not escaped the economic trends. After several years of increase, coincident with increasing advertising rates, the volume of advertising in the *Review* was less than the preceding year, and advertising income for Volume 73 is essentially the same as that in Volume 72. Our frustrations in obtaining effective, aggressive advertising representation

continue. Subscription sales to non-alumni were also less satisfactory than we had hoped, both in terms of initial response to solicitations and in the renewal of existing subscriptions. The *Review* ended the year with about 14,000 non-alumni "paid" subscribers, compared with 10,500 at the end of 1969-70.

ALUMNI RELATIONS PROGRAM

This year there were 11 alumni seminars conducted in six different cities on six different topics as follows: "How To Start and Operate a Small Business" (two cities); "Entrepreneurship Workshop" (five cities); "Chemical Engineering Convocation" (Cambridge); "Career Seminar for M.I.T. Alumni" (Cambridge); "Engineering Opportunities in the Health Care Industry" (Cambridge); and "Providing Energy for the Future" (Cambridge).

This program is a natural extension from the initial three-day seminar developed in 1963 for alumni and wives on the broad theme of the origins of matter, life, and society. The first major style change took place beginning in 1966 when subsequent seminars were on timely topics such as, "Cities in Crisis," "Technology and Medicine," and "Computers in the Service of Society." Last year this report noted another innovation, the two-day seminar on "How to Start and Operate a Small Business." This was a seminar responding to the needs of younger alumni and subsequently repeated in four other cities. The most significant change, however, was that almost all the 125 faculty were alumni; only two were from the M.I.T. faculty.

The quality of the program exceeded all expectations. More importantly, the utilization of alumni faculty, alumni helping alumni, permits an almost unlimited expansion of the alumni seminar programs with little additional drain on M.I.T. faculty as teachers.

New alumni seminar programs are expected to meet the following criteria:

1. To increase alumni participation in M.I.T. activities;
2. To provide opportunities for M.I.T. alumni, students, and faculty to undertake programs of mutual interest;
3. To provide lifetime learning activities for M.I.T. alumni with no additional burden on the M.I.T. faculty;
4. To meet specific needs of alumni groups;
5. To develop a program that can be repeated with little or no change in syllabus from time to time and place to place;
6. To break even financially.

We believe all six of these criteria have been met by this year's programs. There have been exciting lessons: an indication of a vast reservoir

of alumni talent, qualified and immediately willing to participate as "faculty" for such M.I.T. projects; the valuable exchange of views between M.I.T. and alumni participants as teachers on the same program; the success by which these seminars have "converted" alumni who heretofore have had no alumni contact with M.I.T.; the welcome knowledge that such programs can pay their own way. There were other lessons, less encouraging, but no less important. We found we do not have adequate staff to conduct this number of new programs in one year. If similar seminars are to be an important factor in M.I.T.'s continuing education for alumni, then we must somehow obtain a major commitment to the program by responsible academic officers.

This year's annual Alumni Officers Conference, held on campus October 16 and 17, 1970, was devoted to discussion of the work of the Commission on the Nature and the Purpose of an M.I.T. Education. The conference was attended by 439 alumni and wives.

In recognition of Dr. James R. Killian's retirement as Chairman of the M.I.T. Corporation, the Director for Clubs arranged six testimonial meetings for Dr. and Mrs. Killian in New York, Philadelphia, Chicago, Dallas, Mexico City, and San Francisco. These, together with the 1971 Alumni Homecoming in Cambridge, enabled the Killians to meet over 5,000 alumni and guests around the nation during their last year of full-time M.I.T. activities. In addition, there were three alumni meetings in honor of President Howard W. Johnson, and, following the election of Drs. Wiesner and Gray as President and Chancellor, eight events were arranged this spring to introduce them to alumni in other cities.

Two of these major meetings deserve special mention. First, the Spring Concert Series conducted by the M.I.T. Alumni Center of New York attracted over 3,500 alumni and guests to its three events, including over 2,300 who attended the concert of the M.I.T. Symphony Orchestra held at Carnegie Hall on April 19th in special tribute to Dr. Killian. M.I.T.'s program in music was thereby brought to New York, and its quality was testified to not only by those who attended but by the excellent press reviews.

Secondly, Alumni Homecoming weekend in June set another new attendance record of 3,483 alumni and guests. This included 2,116 at the 14 reunions of which a record six were held on the M.I.T. campus, as well as a record 2,982 who attended homecoming activities, including 2,276 who attended the Boston Pops at Symphony Hall.

Through the end of April, 73 speakers have been provided for 43 different M.I.T. clubs, and there was one M.I.T. regional conference held in Washington, D.C. on February 27. Reports from 37 clubs on 86 of their meetings indicate attendance by 2,940 alumni exclusive of wives

and guests. There have been over 50 additional club meetings for which attendance figures are not available.

NOMINATIONS AND ELECTIONS

In the fall of 1970 a Special Committee on Constitution and Bylaws was established to study the procedures for nomination and election of alumni members of the Corporation and of officers of the Alumni Association. This committee is giving particular attention to questions concerning the number of candidates per vacancy and the criteria of age, sex, profession, and geographic location of potential nominees. The committee's report is expected in the fall of 1971.

Simultaneously, the Corporation in March voted to expand its membership by five alumni to be known as Representatives from Recent Classes. They must be two years or less graduated from the Institute at the time of election and will serve five-year terms on the Corporation on a rotating basis. The Secretary of the Alumni Association worked closely with the Corporation Screening Committee to obtain a slate of 14 candidates for the five new vacancies. Subsequently, a ballot was circulated to the 5,800 eligible alumni and the election was completed in time for the names of the five successful candidates to be transmitted to the Corporation for election in June of 1971.

We are pleased to report that the M.I.T. Corporation decided this year to increase the size of the Corporation Visiting Committees by doubling their non-Corporation membership. Therefore, alumni nominees to these 24 committees will increase from 3 to 6 per committee. This, together with the creation of a new Visiting Committee on the Arts will bring alumni membership on visiting committees to 162 persons from the present total of 78.

ALUMNI RECORDS

In the fall of 1969, the Alumni Association and the Office of Administrative Systems initiated a long range study of the future data processing needs of the Alumni Association. The objective was to forecast those needs through 1975 and beyond and to design the administrative and computer requirements necessary to provide future service. The study is now completed and is the basis on which the Association is proceeding to implement a new system during 1971-1972. This is a "third generation system" adaptable to our needs for the decade of the 70's.

As of April 1, the membership rolls included 60,002 names, a net gain of 1,103 over the previous 12 months resulting from adding 1,639 alumni of the Class of 1970, removing the names of 419 alumni reported deceased and removing 117 from the rolls in a continuing effort to refine

our files. During the previous 12 months, 14,804 address changes were recorded. The number of alumni in the "address missing" category totaled 3,616 or 6.0 per cent of our roster.

STAFF CHANGES

Last summer Joseph J. Martori was appointed Administrative Officer for the Alumni Association, filling the vacancy left by John S. Pfeil, Jr.

Miss Helen M. Clifford was promoted to the staff position of Assistant to the Treasurer.

Miss Deborah Shapley, Associate Editor of the *Review* since 1968, resigned during the year to accept a position with the News and Comment staff of *Science* magazine. Her place was taken by Brenda Kelley, who has been for several years the editor of the Class Notes section of the *Review*.

Mrs. Doris S. Evans was promoted to the staff position of Director of Alumni Records, and now, after 34 years of devoted service to the Association, she retires June 30, 1971. I am pleased to report that her kindly and conscientious influence will not be immediately lost to M.I.T., for she has consented to continue in a half-time capacity.

DONALD P. SEVERANCE

THE M.I.T. PRESS

Perhaps the most notable characteristic of fiscal year 1970-71 was its difficulty. That difficulty was not a product of the quality of the books published by the Press, the effectiveness of the presentation of new titles to the trade, or any decline in standards of text editing, design, or production. On the contrary, in 1970-71 the M.I.T. Press issued what may well be the strongest trade list ever presented by a university press, and the internal standards of the past were maintained and in some cases significantly improved. However, general economic conditions and particularly what Carnegie Corporation calls a time of depression in higher education had the effect of reducing net income for the year to $2,434,629 (a drop of approximately 5 per cent, as compared to the previous year), even though gross income, before book returns from stores, was about equal to that of the previous year and even though 34,000 more book units (net) were sold. We did more business; we earned less money. What is more, our budgeted expenses rose, owing to certain essential staff additions, an increased rate of inventory depreciation (itself owing to the sales experience), increases in capital borrowed, and the financial burden of our new building. The result is that

the Press, after three straight years of creating a net operating margin, operated during 1970-71 at a significant deficit.

So did many other presses. According to a column in the *New York Times,* at the close of fiscal 1970-71 "almost without exception, from Harvard to Southern Siwash State, the presses were in financial crisis." Let it be noted that the M.I.T. Press publishes approximately the same number of books as a sister press that maintains a staff more than twice as large as ours. Let it also be noted that, whereas during the most recent year for which figures are available the average university press received in direct and indirect subsidy (excluding subsidy for the publication of individual titles) an amount averaging about 11 per cent of operating cost, the M.I.T. Press receives in direct subsidy nothing and in indirect subsidy less than 2 per cent of operating cost. It is not, therefore, that we are so commodiously staffed that our operating expense is excessive, nor is it that we have operated at a deficit despite heavy subsidy. In the financial area we have done as well as any, better by far than most.

Still, as bookstores, particularly university bookstores, maintain lower inventory levels (and return what they regard as excessive inventory to the publisher), as library budgets, particularly university library budgets, are reduced by 10 per cent or more, as individual students and scholars find themselves less willing to purchase books, as even such indirect subsidies as exist are critically reviewed, as interest rates continue at high levels, and as manufacturing costs, especially cost of composition of complicated scientific text, continue to rise, we must graduate our current publishing program in ways that are new to us and seek additional sources of income in eventual compensation.

During fiscal 1970-71, the Press published 142 and produced, either directly or as imports, 134 new books, bringing the number of titles published to a total of 865 since 1963, when the Press became an independent publishing organization and its connection with John Wiley & Sons was terminated. The number of new hardcover books published during the year indicates an apparent reduction of operating levels as compared to fiscal 1969-70, but it is duration of editing and manufacturing that varied, not the essential level of publishing. During fiscal 1971-72, the Press anticipates publishing 125 new titles: a deliberate turning back calculated to increase the profitability of the publishing operation.

The Press remains among the largest of the American university presses, third or fourth by size according to the measure employed. (The other presses in this rank order are California, Chicago, and Harvard).

In our judgment, all of the books issued during the year were notable:

made, that is, significant contributions to knowledge in their fields and represented appropriately the standards of the broad international attention, including major review or news notice in media like the *New York Times, Newsweek,* and *Time.* Among these were *Beyond Habitat, The First Henry Ford,* the Lukacs *History and Class Consciousness, Roma Barocca, Science in History,* and *Violence and the Police.* Though most of our books were, of course, less noticeable to the general reader, they were perhaps more noticeable to the scholars in their fields; they were less conspicuous but sometimes as important in their impact.

In October, the Press entered its new quarters at 28 Carleton Street. The former offices of the Press were a paradigm of inconvenience, and in the 10,000 square feet it now occupies, laid out specifically to accommodate a publishing operation, there have been clear benefits in quiet, functionalism, and a degree of serenity. Cost of renovation is scheduled to be borne by the Press itself, though it is unlucky that this added expense should occur precisely at this time.

During the year the Editorial Board of the Press, which consists of nine members of the Institute faculty serving for rotating three-year terms, met eight times, considering 135 book projects, of which 125 were approved. It is fitting to recognize the contributions of the three members who will leave the Board at the outset of the new academic year in September, 1971: Dean Robert L. Bishop, School of Humanities and Social Science, chairman of the Board; Professor Ernest Rabinowicz, Mechanical Engineering; and Professor Zenon S. Zannetos, Management.

Certain alterations in the organization of the Press during the year contributed, I believe, to an increased capacity for service. Generally, these changes — and others still in prospect — may be described as being intended to create a constitutional system for the Press, as well as to establish a context in which personal strengths are effectively utilized and corporate opportunities receive decisive response. The Press was separated into operating and support sections. The operating sections were aligned in three main divisions: information acquisition, consisting of project development and evaluation under Michael J. Connolly, editorial director; information processing, consisting of text editing and production, under Harold F. Chevalier, production director; and information dissemination, consisting of sales, advertising, publicity, and order fulfillment, under Rebecca M. McGovern, marketing director. The support sections, among them accounting, credit and collections, and design, provide services for the operating sections, though some support sections, notably design under Muriel Cooper, design director, have important roles of initiative as well.

In our table of organization there is also an as yet unfilled slot for a

director of research and development. It may be obvious that the Press regards its function essentially as information management. Accordingly, having earlier conducted a pilot project in basic text editing, we now look forward to undertaking an augmented pilot program in machine-assisted editing, formatting, and composition. I believe that a machine resource may permit increased speed of processing of conventional information units while opening avenues of systems development that ought to be of vital concern to contemporary publishers. In micropublication, in videorecording, and in many others of the new technologies, options exist the proper exploitation of which will require explicit administrative provision.

At June 30, 1971, the strength of the Press was 64 regular employees as against 57 at the same time in the previous year.

Categorized broadly, the acquisitions effort of the Press shows the following development, as compared to the previous year:

	1969-70	1970-71
Social Science	28%	26%
Humanities	15%	12%
Engineering	24%	28%
Science and Mathematics	16.5%	26%
Art and Architecture	16.5%	13%

The rise in the number of works in science and mathematics acquired is deliberate and welcome. It it still true that we publish more works in science and engineering than any other university press but that the diversity of our list — which enters sixty-five disciplines and subdisciplines — communicates something of the richness of the Institute itself as a center of learning.

During the fiscal year that is the subject of this report, the information acquisitions division reviewed 1,650 book projects, half again as many as the year before, of which 1,525 were declined, just over a thousand by the acquisitions staff alone, nearly five hundred more as a result of review by scholar-consultants. Ten projects presented to the Board were not approved by it, though sometimes the Board merely deferred action pending further investigation. Publication under the M.I.T. imprint is obviously much sought, rarely allowed. The information explosion is for the Press not an abstract condition, and the problem of exercising refined judgments of manuscript quality and significance when volume is so high is one that has been dealt with by the acquisitions staff with remarkable skill in the past but that will weigh heavily upon it in the future.

Finding and developing new books is a function at the very heart of the operation of the Press, and as time goes on we may wish to explore new varieties of relationship to the faculty of the Institute, upon whom we depend as scouts and judges.

Eighty-two new book contracts were signed, 17 new translation agreements. Overall, 115 of our titles have been translated into at least one foreign language, one measure among many of the international reach of the Press.

The editorial department, now under Helen I. Osborne as managing editor, during Fiscal 1970-71 processed in some stage 142 titles. Thirty thousand manuscript pages were edited in-house, an additional 6,000 pages by free-lance editors under the supervision of the chief editor, Ruth Gillies, or a senior editor.

With regard to pace of editing and pace of production, one book, *Man's Impact on the Global Environment,* was issued in two months, and two more books were issued in a little less than and a little more than three months, respectively. The production department, under its manager Dwight E. Agner, was asked during the year to undertake the manufacture of a substantial number of difficult or unusual books. Though the level of its activity in terms of titles processed remained about constant, such projects combined with the need in some instances for accelerated schedules of the kind described above to create substantial burdens faithfully carried by Mr. Agner and his staff.

The design department, responsible not only for book design but for design of advertisements, brochures, and exhibits, among other projects, succeeded in maintaining what may very well be the highest design standard practiced by any house in America. The recognition of the graphic excellence achieved by M.I.T. Press continues to be substantial: three titles in 1970-71 were cited by the American Institute of Graphic Arts, seven by the Association of American University Presses, two by the New England Book Show, and three by the Type Directors Club of New York.

During 1970-71, the marketing effort of the Press produced the highest return ever on our marketing investment:

	1967-68	1968-69	1969-70	1970-71
Total marketing expense	$ 320,000.00	315,000.00	488,000.00	402,000.00
Sales	1,610,000.00	1,904,000.00	2,572,000.00	2,453,000.00
Volume per dollar of marketing expense	5.03	6.04	5.27	6.10

During fiscal 1970-71, we dispatched 1,528,000 mailing pieces, once again indicating a heavy reliance on direct mail, with the precision of aim that it affords. We prepare modular copy which is employed, often by the duplication not only of content but of type itself, for a variety of advertising purposes, resulting in important economies. During the year we produced 112 advertisements. We distributed 102,000 copies of our catalogues.

I have already mentioned the excellent reviews we earned during the year, which are as much an announcement of the quality of the Institute as of the Press and individual books published by it. Eleven thousand books were sent out for review in that space of time.

Our books were shown at 34 major exhibits, principally at scholarly meetings. On 11 sites we had our own booth; on the remainder the exhibit was cooperative. Because our booth is prepared with the same emphasis on design that characterizes our books, it is often a center of attention.

Our field sales force called on 549 bookstores and wholesalers once, on 650 four times, in 40 states, working up suggested orders and laboriously checking inventory. Our standing order and agency plans now serve 374 accounts.

Our London operation, joint with the University of Chicago Press and serving U.K., Continental Europe, the Middle East, and Africa registered pleasing sales of $350,000 (the book economy remains firm overseas), a 13 per cent increase over the previous year. Under London manager Graham Voaden, this enterprise therefore accounted for 14 per cent of our total sales.

The M.I.T. Press now maintains in conventional print 773 titles (all out-of-print titles remain available through the Press in Xerox copy). Of the registered inventory items, only 115 sold more than 1,000 copies during the year, and 58 of *those* were paperbacks. Only 11 sold more than 5,000 copies, including 9 numbered paperbacks. One hardcover book, Moshe Safdie, *Beyond Habitat,* and one unnumbered paperback, Boston Society of Architects, *A Guidebook to Boston,* sold more than that number in the year. Two paperbacks sold more than 10,000 copies. We are, then, as we have been, scholarly publishers, generally selling single books in specialized fields to professional or academic buyers.

HOWARD R. WEBBER

PRINCIPAL PROFESSIONAL HONORS AND ACTIVITIES OF THE STAFF

INSTITUTE PROFESSORS

MARTIN J. BUERGER
Isidor Fankuchen Memorial Award, American Crystallographic Association.

SCHOOL OF ARCHITECTURE AND PLANNING

DEPARTMENT OF ARCHITECTURE

STANFORD ANDERSON
Graham Foundation Visiting Fellow, Institute for Architecture and Urban Studies, New York City
Fellow, Institute for Architecture and Urban Studies.

ALBERT G. H. DIETZ
International Award in Plastics Science and Engineering, Society of Plastics Engineers.

HENRY A. MILLON
Vice-President, University Film Study Center.

MINOR WHITE
Honorary Doctorate, Maryland Institute of Art.
John Simon Guggenheim Memorial Foundation Fellowship.

DEPARTMENT OF URBAN STUDIES AND PLANNING

ROBERT M. FOGELSON
Fellow, Social Science Research Council.

BERNARD J. FRIEDEN
Member, Editorial Advisory Panel, *Journal of the American Institute of Planners.*
Trustee, National Assembly for Social Policy and Development.

LAWRENCE E. SUSSKIND
Student Award, American Institute of Planners.
Goodwin Award, Massachusetts Institute of Technology.

SCHOOL OF ENGINEERING

DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS

FINSTON MORTON
Overseas Fellow, Churchill College, Cambridge University, England.

THEODORE H. H. PIAN
Member, Technical Committee on Structural Dynamics, American Institute of Aeronautics and Astronautics.

WALLACE E. VANDER VELDE
Member, Board of Directors, New England Section, American Institute of Aeronautics and Astronautics.

DEPARTMENT OF CHEMICAL ENGINEERING

LAWRENCE B. EVANS
Vice-Chairman, Computer Aids in Chemical Engineering Education Committee, National Academy of Engineering.

EDWIN R. GILLILAND
Fellow, American Institute of Chemical Engineers.
Founders Award, American Institute of Chemical Engineers.

MICHAEL S. MORGAN
Member, Society of Sigma Xi.

ROBERT C. REID
Director, American Institute of Chemical Engineers Council
Distinguished Alumni Award, Purdue University.

CHARLES N. SATTERFIELD
Kelly Lecturer, Purdue University.
Member, Committee on Air Quality Management and Chairman, *Ad Hoc* Panel on Abatement of Nitrogen Oxide Emissions from Stationary Sources, National Academy of Engineering.
Member, Editorial Board, *Advances in Chemistry* Series.

GLENN C. WILLIAMS
President, The Combustion Institute.

DEPARTMENT OF CIVIL ENGINEERING

JOHN T. CHRISTIAN
Member, Committee on Computer Applications, Soil Mechanics and Foundations Division, American Society of Civil Engineers.
Associate Editor, Newsletter, Soil Mechanics and Foundations Division, American Society of Civil Engineers.
Member, Executive Committee, Computer Division Boston Society of Civil Engineers.

RUSSEL C. JONES
National Director, District 2, American Society of Civil Engineers.

CHARLES C. LADD
Chairman, Geotechnical Section, Boston Society of Civil Engineers.

FRED MOAVENZADEH
Sanford E. Thompson Award, American Society for Testing and Materials.

JOHN C. SCHAAKE JR.
Secretary, Urban Water Resources Research Council, American Society of Civil Engineers.

DEPARTMENT OF ELECTRICAL ENGINEERING

DAVID ADLER
Member, Editorial Board, *Journal of Nonmetals.*

MICHAEL ATHANS
Member, Administrative Committee, Institute of Electrical and Electronics Engineers, Control Systems Society.
Vice President, Institute Electrical and Electronics Engineers, Control Systems Society.
Associate Editor, *Automatica.*
Member, Donald P. Eckman Award Committee, American Automatic Control Council.

JOHN S. BARLOW
President-Elect, Eastern Association of Electroencephalographers.

ABRAHAM BERS
Member, Executive Committee, and Chairman, Nominating Committee, Division of Plasma Physics, American Physical Society.

BARRY A. BLESSER
Vinton Hayes Post Doctoral Fellowship.

BRIAN E. BOYLE
Fellowship, National Science Foundation.

STEPHEN K. BURNS
Chairman, Boston Section, Chapter of Group on Engineering in Medicine and Biology, Institute of Electrical and Electronics Engineers.

CHARLES K. CRAWFORD
Chairman, New England Section, American Vacuum Society.

ROBERT R. FENICHEL
Chairman, Committee S, Massachusetts State Conference, American Association of University Professors.

JOSEPH FERREIRA, JR.
Member, Society of Sigma Xi.

LAWRENCE S. FRISHKOPF
Fellow, Acoustical Society of America.

JULIUS L. GOLDSTEIN
Member, Committee on Psychological and Physiological Acoustics, Acoustical Society of America.

MARTIN E. HELLMAN
Vinton Hayes Fellowship.

WILLIAM V. HERRICK
Member, Society of the Sigma Xi.

JIN AU KONG
Member, New York Academy of Science.
Secretary and Treasurer, Phi Tau Phi Scholastic Honor Society.
Listed in *American Men of Science* and *Community Leaders of America.*

RICHARD C. LARSON
Vice Chairman, Boston Section, System Science, Man, and Cybernetics, Institute of Electrical and Electronics Engineers.

FRANCIS F. LEE
Fellow, Institute of Electrical and Electronics Engineers.
Vice Chairman, Computer Group, Boston Section, Institute of Electrical and Electronics Engineers.

FREDERICK J. LEONBERGER
Member, Society of Sigma Xi.

FREDERIC R. MORGENTHALER
Chairman, Professional Group on Microwave Theory and Techniques, Boston Section, Institute of Electrical and Electronics Engineers.

ALAN V. OPPENHEIM
Vice Chairman, Technical Activities Group on Audio and Electroacoustics, Institute of Electrical and Electronics Engineers.

PAUL PENFIELD, JR.
Vice-Chairman, Boston Section, Institute of Electrical and Electronics Engineers.

JAMES K. ROBERGE
Best Paper Award, 1970, Society for Information Display Symposium.

LEO J. ROTENBERG
Member, Society of Sigma Xi.

JACK PHILIP RUINA
Fellow, American Academy of Arts and Sciences.

WILLIAM F. SCHREIBER
Leonard G. Abraham Prize Paper, Communication Technology Group, Institute of Electrical and Electronics Engineers.

JAN C. WILLEMS
Chairman, Nonlinear and Distributed Parameter Systems Committee, Institute of Electrical and Electronics Engineers Society on Control Systems.
Associate Editor, *IEEE Transactions on Automatic Control.*

GERALD L. WILSON
Hickernell Award, Institute of Electrical and Electronics Engineers.

DEPARTMENT OF MECHANICAL ENGINEERING

JAMES A. FAY
Fellow, American Institute of Aeronautics and Astronautics.

JOHN B. HEYWOOD
Ralph R. Teetor Award, Society of Automotive Engineers.

ANTHONY C. LUNN
Phillips Graduate Fellowship.

ROBERT W. MANN
Member, Institute of Medicine, National Academy of Science.

EGON OROWAN
Vincent Bendix Award, American Society Engineering Education.

RONALD F. PROBSTEIN
Freeman Award in Fluids Engineering for 1971, American Society of Mechanical Engineers.

JOSEPH L. SMITH, JR.
Process Industries Division Award, American Society of Mechanical Engineers.

JOSEPH L. SMITH, JR.
Russell B. Scott Memorial Award.

LARRY M. SWEET
Member, Society of Sigma Xi.

PHILIP THULLEN
Russell B. Scott Memorial Award.
Process Industries Division Award, American Society of Mechanical Engineers.

DANIEL E. WHITNEY
DuPont Associate Professor.

DAVID GORDON WILSON
Member, American Public Works Association.
Member, Ecological Advisory Group, Massachusetts Institute of Technology.

TAU-YI TOONG
President, East America Chapter, The Phi Tau Phi Scholastic Honor Society.
Vice President, The Phi Tau Phi Scholastic Society.
Member, Editorial Advisory Board, *Combustion Science and Technology.*

DEPARTMENT OF METALLURGY AND MATERIALS SCIENCE

BENJAMIN L. AVERBACH
Fellow, American Society of Metals.
Vice President, International Conference on Fracture.

JOHN CHIPMAN
Doktor, Ingenieurs Ehren halber, Rheinisch, Westfalische Technische Hochschule, Aachen, Germany.

MORRIS COHEN
Robert S. Williams Lectures, Department of Metallurgy and Materials Science, Massachusetts Institute of Technology.
Gold Medal, Japan Institute of Metals.
Honorary Membership, Iron and Steel Institute of Japan.
Distinguished Service Award, ASM Student Chapter, Youngstown State University.
Pierre Chevenard Medal, Societe Francaise de Metallurgie.
Trustee and Past President American Society for Metals.

GAURI C. DAS
Member, Society of Sigma Xi.

MERTON C. FLEMINGS
Abex Professor of Metallurgy and Materials Science.
Member, Composite Materials Activity, American Society for Metals.

CHARLES A. GOODWIN
Student Representative, New England Section, American Ceramic Society.

ROBERT MEHRABIAN
Member, Solidification Committee, Institute of Metals Division, Metallurgical Society, American Institute of Mining, Metallurgical, and Petroleum Engineers.

MICHAEL D. RECHTIN
IBM Postdoctoral Fellowship.

ROBERT M. ROSE
Vice-Chairman, Boston Chapter, American Society of Metals.

WILLIAM D. ROSENBERG
Member, Society of Sigma Xi.

KENNETH C. RUSSELL
Vice Chairman, Physics and Chemistry of Metals Committee, American Institute of Mining, Metallurgical, and Petroleum Engineers.
Vice President, M.I.T. Chapter, Society of Sigma Xi.

DEPARTMENT OF NUCLEAR ENGINEERING

ELIAS P. GYFTOPOULOS
Member, Commission on Education, National Academy of Engineering.
Trustee, Anatolia College, Salonica, Greece.

KENT F. HANSEN
Member, Board of Directors, American Nuclear Society.

ALLAN F. HENRY
Chairman, Honors and Awards Committee, American Nuclear Society.

DAVID D. LANNING
Chairman, Student Program, 17th Annual Meeting, American Nuclear Society.

DAVID J. ROSE
Director of Long Range Planning, Oak Ridge National Laboratory.
Member, Group on Social Directions for Technology, Commission on Education, National Academy of Engineering.

DEPARTMENT OF OCEAN ENGINEERING

MARTIN A. ABKOWITZ
President, M.I.T. Chapter, Society of Sigma XI.
Visiting Professor, University of Sao Paulo, Brazil.

PATRICK LEEHEY
Visiting Professor, Max-Planck-Institut für Strömungsforschung, Göttingen, Germany.

PHILIP MANDEL
Visiting Professor, University College, London, England.

SCHOOL OF HUMANITIES AND SOCIAL SCIENCE

DEPARTMENT OF ECONOMICS

THEODORE E. KEELER
Key fellowship, Joint Center for Urban Studies of Massachusetts Institute of Technology and Harvard University.
Fellow, National Science Foundation.

DEPARTMENT OF FOREIGN LITERATURES AND LINGUISTICS

WILLIAM F. BOTTIGLIA
Member, Advisory Committee, Sweet Briar Junior Year in France.
President, Xi of Massachusetts Chapter, Phi Beta Kappa Society.

NOAM CHOMSKY
Honorary Doctor of Humanities, Bard College.

MARTIN DYCK
Chairman, Sektion Linguistik und Philologie 1, Fourth International Congress of Germanic Studies, Princeton.

DEPARTMENT OF HUMANITIES

DAVID M. EPSTEIN
Composer's Award, American Society of Composers, Authors, and Publishers.
Ford Foundation Recording Grant.
Guest Conductor, Gulbenkian Chamber Orchestra, Lisbon.

ROBERT S. FREEMAN
Chairman, New England Chapter, American Musicological Society.
Marion and Jasper Whiting Foundation Research Grant.

LOUIS KAMPF
President, Modern Language Association of America.

LILLIAN S. ROBINSON
Member, Resolutions Committee, Modern Language Association of America.

NATHAN SIVIN
John Simon Guggenheim Memorial Foundation Fellowship.
Advisory Editor for Far Eastern Science, *Isis*.
Member, Steering Committee, Second International Conference on Taoism, Hong Kong.

CYRIL STANLEY SMITH
Vice President, Chairman of Section L (History and Philosophy of Science), American Academy of Arts and Sciences.
Penrose Lecturer, American Philosophical Society.

HUSTON C. SMITH
Honorary Doctor of Letters, Hobart and William Smith Colleges.

BARRY SPACKS
St. Botolph's Arts Award.

DEPARTMENT OF PHILOSOPHY

GERALD B. DWORKIN
Old Dominion Fellowship.

IRVING SINGER
Rockefeller Foundation Grant.
Senior Examiner, College of Letters, Wesleyan University.

DEPARTMENT OF POLITICAL SCIENCE

HAYWARD R. ALKER JR.
Chairman, Mathematical Social Sciences Board.
Member, Nominating Committee, American Political Science Association.

LINCOLN P. BLOOMFIELD
Member, President's Commission for the Observance of the 25th Anniversary of the United Nations.
Member, Board of Directors, United Nations Association of the U.S.A.
Member, Board of Directors, World Affairs Council of Boston.
Member, Board of Editors, *International Organization.*
Co-chairman, Harvard-M.I.T. Joint Arms Control Seminar.

FREDERICK W. FREY
Fellow, Center for Advanced Study in the Behavioral Sciences.

TED R. GREENWOOD
Member, Society of Sigma Xi.
Scholarship, Canadian Department of National Defence.
Grant, Fund for Peace Research.

DANIEL LERNER
Member, Executive Committee, and Conference Chairman, World Association of Public Opinion Research.

LUCIAN W. PYE
Chairman, Committee on Comparative Politics, Social Science Research Council.
Vice President, Committee on U.S./China Relations.
Member, Board of Directors, Council on Foreign Relations, Asia Foundation, Asia Society, University Services Centre (Hong Kong), SEADAG.

ROBERT I. ROTBERG
John Simon Guggenheim Memorial Foundation Fellowship.

EUGENE B. SKOLNIKOFF
Fellow, American Academy of Arts and Sciences.
Chairman and President, Science and Public Policy Studies Group.
Member, Council, Federation of American Scientists.

DEPARTMENT OF PSYCHOLOGY

RICHARD M. HELD
Member, Society of Experimental Psychologists.

RONALD E. KALIL
Fellowship, National Institutes of Health.

WHITMAN A. RICHARDS
Fellow, Optical Society of America.
Member, Honorary Editorial Advisory Board, *Vision Research.*

ALFRED P. SLOAN SCHOOL OF MANAGEMENT

GORDON F. BLOOM
Director, Boston Chapter, American Marketing Association.
Member, Committee on Socioeconomic Data, National Research Council.
Member, Food Retailing Advisory Committee, Office of Emergency Preparedness.
Member, Executive Committee and Board of Directors, National Association Food Chains.
Member, Planning Board, City of Newton, Massachusetts.
Gabrielson Lectures, Colby College.

JOHN F. COLLINS
Combined Industries Good Scout Award, Boston Council, Boy Scouts of America.
First Vice President, Boston Chamber of Commerce.

WARREN H. HAUSMAN
Associate Editor, *Management Science.*
Member, Society of Sigma Xi.

DANIEL Q. MILLS
Everett Moore Baker Award, Massachusetts Institute of Technology.

FRANCO MODIGLIANI
Institute Professor, Massachusetts Institute of Technology.
Vice President, American Economic Association.
Member, Executive Committee, Behavioral Sciences Division, National Research Council.
Member of Comitato Per le Scienze Politiche e Sociali.

WILLIAM F. POUNDS
Fellow, American Academy of Arts and Sciences.

EDWARD B. ROBERTS
Presidential Citation, Massachusetts Institute of Technology Alumni Association.

KENAN E. SAHIN
Salgo-Noren Award for Excellence in Teaching.

JEREMY F. SHAPIRO
Associate Editor, *Management Science.*

ZENON S. ZANNETOS
National Chairman, Executive Committee, College on Measurements in Management, TIMS.
Member, Board of Editors, *Decision Sciences.*
Member, Board of Editors, *Cybernetic Journal.*

SCHOOL OF SCIENCE

DEPARTMENT OF BIOLOGY

DAVID BALTIMORE
Warren Triennial Prize.
Eli Lilly and Company Award in Microbiology and Immunology.

BOR-SHYUE HONG
Member, American Chemical Society.
Member, Society of the Sigma Xi.

SUNG KIM
SIDHU Award, Pittsburgh Diffraction Conference.

IRVING M. LONDON
Member, National Academy of Sciences.
Member, Executive Committee, Institute of Medicine, National Academy of Sciences.

DEPARTMENT OF CHEMISTRY

ROBERT A. ALBERTY
Vice Chairman, Division of Biological Chemistry, American Chemical Society.

LAWRENCE J. HEIDT
Member, Board of Directors, Northeastern Section, American Chemical Society.
Visiting Professor, University of Islamabad West Pakistan.
Chairman, Photochemistry Conference, Ohio State University.

RICHARD H. HOLM
Fellow, American Academy of Arts & Sciences.
Visiting Professor of Chemistry, Stanford University.

DANIEL S. KEMP
Dreyfus Foundation Equipment Grant.

JOHN ROSS
Appointed Frederick George Keyes Professor of Chemistry, Massachusetts Institute of Technology.

MWINDAACE N. SIAMWIZA
Staff Development Fellowship, University of Zambia, Lusaka, Zambia.

DEPARTMENT OF EARTH AND PLANETARY SCIENCES

KEITI AKI
Member, Board of Directors, Seismological Society of America.

ROGER G. BURNS
Member, Editorial Board, *Chemical Geology*.
Fellow, Mineralogical Society of America.
Research grants from NASA and NSF for spectral measurements of minerals.

DAE-HYUN CHUNG
Founder Member, American Academy of Mechanics.
Member, National Science and Technology Development Board, Government of the Republic of Korea.
Achievement Award, Geological Survey of Korea.

RICHARD S. NAYLOR
Secretary-Treasurer, Boston Geological Society.

GORDON H. PETTENGILL
President, Commission 16, "Physics of the Planets", International Astronomical Union.

ROBERT R. SHROCK
Honorary degree of Doctor of Science, Indiana University.

DAVID R. WONES
Councilor, Mineral Society of America.
Councilor, Geochemical Society.
Vice Chairman, U.S. National Committee on Geochemistry.

CARL I. WUNSCH
James B. Macelwane Award, American Geophysical Union.

DEPARTMENT OF MATHEMATICS

EYTAN BAROUCH
Member, American Physical Society.

IRWIN BLAU
Applied Mathematics Fellowship.

MICHAEL J. FISCHER
Special Issue Editor, *Journal of Computer and System Sciences*.
Secretary-Treasurer, Association for Computing Machinery Special Interest Group on Programming Languages.

ELLIOTT H. LIEB
Boris Pregel Award in Chemical Physics, New York Academy of Sciences.

WILLEM V. R. MALKUS
John Simon Guggenheim Memorial Foundation Fellowship.

DAVID B. MEREDITH
Grant, National Science Foundation.

GIAN-CARLO ROTA
André Aisenstadt Visiting Professor of Mathematics, Université de Montreal.
Taft Lectures, University of Cincinnati.
Fellow, Institute of Mathematical Statistics.

RICHARD D. SCHAFER
Chairman, Northeastern Section, Mathematical Association of America.

DEPARTMENT OF METEOROLOGY

JAMES M. AUSTIN
Fellow, American Meteorological Society.

JULE G. CHARNEY
International Meteorological Organization Prize.
Foreign member, Norwegian Academy of Sciences.

DELBAR P. KEILY
Member, Board of Admissions, American Meteorological Society.

ROBERT A. KNOX
Member, Society of Sigma Xi.

ERIK L. MOLLO-CHRISTENSEN
Von Karman Award 1970, American Institute of Aeronautics and Astronautics.

REGINALD E. NEWELL
Fellowship, National Science Foundation.

NORMAN A. PHILLIPS
Carl-Gustav Rossby Research Medal, American Meteorological Society.

DEPARTMENT OF NUTRITION AND FOOD SCIENCE

ARNOLD L. DEMAIN
Chairman, Division of Environmental & Applied Microbiology, American Society for Microbiology.
Member, Advisory Board, *Biotechnology & Bioengineering*.
Member, Editorial Board, *Antimicrobial Agents & Chemotherapy*.
Councilor, Northeast Branch, American Society for Microbiology.

JAMES F. DRUMMOND
President, Boston Chapter, International Association for Dental Research.

SAMUEL A. GOLDBLITH
Fellow, Institute of Food Technologists.

JOHN E. GORDON
Honorary Fellowship, American College of Preventive Medicine.
Honorary Fellowship, International Epidemiological Association.

PHILLIP ISSENBERG
Member, Executive Committee, Division of Agricultural and Food Chemistry, American Chemical Society.

THEODORE P. LABUZA
Outstanding Teaching Award, Massachusetts Institute of Technology.

SANFORD A. MILLER
Chairman, Northeast Section, Institute of Food Technologists; Perinatal Research Society; Society of Pediatric Research.

PAUL M. NEWBERNE
President, American College Veterinary Pathologists.
Chairman, Research Council, American Veterinary Medical Association.

ERNST R. PARISER
Member, Advisory Committee for Technology Innovation and Monitoring Program, National Academy of Sciences.

NEVIN S. SCRIMSHAW
Chairman, Protein Advisory Group of the UN System.
Member, National Academy of Sciences.
Member, WHO Advisory Committee on Medical Research.
Council Member, American Public Health Association.

ANTHONY J. SINSKEY
Associate Editor, *International Journal of Radiation Sterilization.*

BETTE F. WEISS
Member, Society of Sigma Xi.

EMILY L. WICK
Chairman Elect, Division of Agricultural & Food Chemistry, American Chemical Society.

DEPARTMENT OF PHYSICS

WILLIAM P. ALLIS
Visiting Professor, University of Southern Florida.
Member, Sigma Pi Sigma.

ALAN H. BARRETT
Corecipient, Count Rumford Award, American Academy of Sciences.

GEORGE BEKEFI
Visiting Professor, University of Quebec.
Fellow, American Physical Society.
Fellow, Society of Sigma Xi.

GEORGE B. BENEDEK
Member, Governing Board, American Institute of Physics.

SANBORN C. BROWN
Charter Member, and Secretary-Historian, M.I.T. Phi Beta Kappa Chapter.
Vice-Chairman, U.S. National Committee for the International Union of Pure and Applied Physics.

ROBLEY D. EVANS
President-elect, Health Physics Society.

JEROME I. FRIEDMAN
Fellow, American Physical Society.

THOMAS J. GREYTAK
Alfred P. Sloan Research Fellowship.

KENNETH A. JOHNSON
John Simon Guggenheim Memorial Foundation Fellowship.

WILLIAM J. JONES
Trustee, Southeastern Massachusetts University.

ARTHUR K. KERMAN
Associate Editor, *Reviews of Modern Physics.*
Member, Nuclear Physics Division, American Physical Society.

JOHN G. KING
E. Harris Harbison Award for Gifted Teaching.

VERA KISTIAKOWSKY
Chairwoman, Committee on Women in Physics, American Physical Society.

DANIEL KLEPPER
Member, Advisory Committee on Fundamental Constants, National Research Council.
Member, Organizing Committee, Third International Conference on Atomic Physics.
Member, Program Committee, Division of Electron and Atomic Physics, American Physical Society.

J. DAVID LITSTER
John Simon Guggenheim Memorial Foundation Fellowship.

ROBERT O. MASTALIR
Member, Society of Sigma Xi.

BRUNO B. ROSSI
1970 Gold Medal of the Italian Physical Society.
Honorary Fellow, Tata Institute of Fundamental Research.
International "Feltrinelli" Award, Accademia dei Lincei.

GARY HILTON SANDERS
Member, Society of Sigma Xi.

CLIFFORD G. SHULL
Member, New York Academy of Sciences.

MALCOLM W. P. STRANDBERG
Professeur Invité, The University of Geneva.

VIGDOR L. TEPLITZ
Ford Foundation Summer Fellowship.

SAMUEL C. C. TING
Associate Editor, *Nuclear Physics B.*

WILLIAM E. TURCHINETZ
Chairman, Gordon Conference on Photonuclear Reactions.

VYTENIS M. VASYLIUNAS
Associate Editor, *Journal of Geophysical Research.*
Member, U. S. Commission 4 (on the Magnetosphere) of the International Scientific Radio Union.

STEVEN WEINBERG
Councilor-at-Large, American Physical Society.
Member, Committee on Research Funds, American Academy of Arts and Sciences.
Consultant, U.S. Arms Control and Disarmament Agency.

ADMINISTRATION

JOSEPH M. DAGNESE
Chapter Liaison Officer, Special Libraries Association.
Library Consultant, Ford Foundation, Delhi University Library (India).

ROBERT V. DODD
Member, National Committee on Public Relations.
Member, National Association of Accountants.

BARBARA F. FRICK
Member, Beta Phi Mu.

VINCENT A. FULMER
Honorary degree of Doctor of Laws, Suffolk University.
Trustee, Institute of Social Technology of Puerto Rico.
Treasurer, Xi of Massachusetts Chapter, Phi Beta Kappa.
Secretary, Planning Office, Urban Affairs Foundation, Inc.

WOLCOTT A. HOKANSON
Treasurer, Deerfield, New Hampshire, Fair Association, Inc.

JAMES R. KILLIAN, JR.
Prometheus Award, National Electrical Manufacturers Association.

WILLIAM N. LOCKE
Chairman, Membership Committee, Association of Research Libraries.
Chairman, Committee on Constitution and Bylaws, American Society for Information Science.
Member, U.S. National Committee for the International Federation for Documentation.

FRANCES R. L. NEEDLEMAN
Secretary, Cataloguing and Classification Section, Resources and Technical Services Division, American Library Association.
Member, Executive Committee, Membership Committee, American Library Association.

IRWIN W. SIZER
Honorary degree of Doctor of Science, Brown University.

MEDICAL DEPARTMENT

ROLAND E. HOULE, M.D.
Secretary, Massachusetts Ophthalmological Society.

ALFRED J. R. KOUMANS
Member, Committee on Mental Health, Massachusetts Medical Society.

RENEE BENNETT O'SULLIVAN, M.D.
Diplomate, American Board Plastic Surgery.

MELVIN H. RODMAN
President, Massachusetts Tuberculosis and Respiratory Disease League.

EDWIN W. SALZMAN
Member, American Society for Clinical Investigation.

ROBERT F. TILLEY
Assistant Treasurer, Massachusetts Medical Society.
Trustee, Boston Medical Library.

OTHER OFFICES, CENTERS DEPARTMENTS, AND LABORATORIES

RICHARD H. BAKER
Member, 1971 International Solid State Circuit Conference Program Committee (ISSCC).
Guest Editor, *IEEE Journal of Solid State Circuits, February, 1971.*

ROBERT M. BYERS
Incentive Award, American College Public Relations Association.

MURIEL R. COOPER
Chairwoman, American Institute of Graphic Arts 50 Books of the Year Show, 1971.
Member, Committee on Design and Production and Member, Committee on Education, American Association of University Presidents.

GEORGE F. DALRYMPLE
Member, Society of Sigma Xi.

PAOLO DI VECCHIA
NATO Fellowship.

RICHARD PATRICK DOBER
President, Boston Architectural Center.
Member, Board of Overseers, Shady Hill School, Cambridge, Massachusetts.
Grant, National Foundation for the Arts.

HERMAN FESHBACH
Chairman, Division of Nuclear Physics, American Physical Society.
Member, National Research Council.
Member, Committee on Nuclear Science, National Research Council.
Member, Executive Committee, Division of Physical Sciences, Washington, D.C.

NICHOLAS JOHN GRANT
Member, Committee on Research, NASA, Washington, D. C.
Member, Committee on Research, American Society for Testing and Materials.

EVERETT E. HAGEN
Member, Committee on Meetings, American Academy of Arts and Sciences.

GEORGE R. HARRISON
William F. Meggers Medal, Optical Society of America.
Geoffrey Frew Fellowship, Australian Academy of Science.

JOHN D. C. LITTLE
Council Member, Operations Research Society of America.
Chairman, Transportation Science Section, Society of America.
Honorable Mention, Lanchester Prize for Best Paper in Operations Research in 1970.

PAULA MENYUK
Award, Australian-American Educational Foundation.

ROBIN ALISON REMINGTON
Member, Academic Exchange with the Belgrade Institute of International Politics and Economics, Belgrade, Yugoslavia, October 1970-July 1971.

FRANCIS O. SCHMITT
Honorary degree of Doctor of Science, New York Medical College.

HERBERT W. SCHNOPPER
Member, New York Academy of Sciences.

ROSS H. SMITH
Representative, New England Division, National Collegiate Athletic Association.
Vice-President and Chairman, Constitution Committee, Eastern College Athletic Conference.
Vice Chairman and Chairman, Development Committee, United States Olympic Rowing Committee.

REBECCA L. TAGGART
Chairman-Elect, Engineering Division, Special Libraries Association.

WEN-YING TSAI
Design in Steel Award, 1971, "Best Fine Art in Steel," American Iron & Steel Institute

CHARLES H. STEVENS
Consultation Officer, Boston Chapter, Special Libraries Association.
Council Member, American Library Association.

FREDERIC G. WORDEN
Fellow, American Academy of Arts and Sciences.

FRANCIS BITTER NATIONAL MAGNET LABORATORY

KENNETH J. BUTTON
Member, Review Board, *The Microwave Journal.*
Member, Advisory Board, *Journal of Crystal Growth.*
Member, Advisory Committee, Electronic Properties Information Center.

SIMON FONER
Visiting Committee Member, Department of Physics, Carnegie-Mellon University.
Member, Committee on Solid State Physics, Advisory to U.S. Army Research, Office, National Academy of Sciences.
Director, NATO Advanced Study Institute, La Colle sur Loup, France.
Member, Organizing Committee, International Conference on Low Temperature Physics, 1972.
Committee Member, Solid State Physics, American Physical Society.
Member, Editorial Advisory Board, *International Journal of Magnetism.*

LAWRENCE G. RUBIN
Member, Editorial Board, *Review of Scientific Instruments.*
Representative, Program Committee of 5th Temperature Symposium, June 21-24, Washington, D. C., American Institute of Physics.
Member of Program Committee, Chairman of Nominating Committee, and Chairman of Fellow Committee, Boston Chapter, Professional Group on Instrumentation and Measurement, Institute of Electrical and Electronics Engineers.
Member, Morris Leeds Award Subcommittee, Field Awards Committee, Institute of Electrical and Electronics Engineers.

DRAPER LABORATORY

RICHARD H. BATTIN
Fellow, American Institute of Aeronautics and Astronautics.

MICHAEL BUCZACZER
Member, Society of the Sigma Xi.

CHARLES S. DRAPER
Founders Medal, National Academy of Engineering.
Thomas D. White National Defense Award, U. S. Air Force Academy.
Honorary Doctor's Degree, University of Portland.
Distinguished Civilian Service Medal, Department of Defense.
Charles F. Kettering Award, PTC Research Institute of George Washington University.
Elmer A. Sperry Award, Sperry Board of Award.
Distinguished Service Citation, American Ordnance Association.

JOHN R. STEMNISKI
Chairman, Subcommittee F7.03 Gyro Fluids, American Society for Testing and Materials.

LINCOLN LABORATORY

BERNARD GOLD
Fellow, Acoustical Society of America.

BRUCE K. L. WILLARD
Vice President, Boston Chapter, National Association of Accountants.