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A state without the means of some change is without the means of its conservation.

– Edmund Burke, Reflections on the Revolution in France

American higher education must address the challenges of a new era. This requires not only introspection regarding our mission and the changing environment in which we serve society, but also rethinking our relationship and interaction with both industry and the federal government. Global economic competition and accelerating social and technological change have altered much of what is needed in our educational and research programs. Changing national priorities and attitudes, including an increasingly pervasive cynicism, are remaking the landscape of federal science and technology policy, with strong ramifications for our universities.

We must enthusiastically address the challenges of this new era, yet it is essential that fundamental values of the academy not become victims of short-term or localized thinking, despite the necessity for evolution and change within the system of higher education. Likewise, commitment to academic values must not imply rigidity and resistance to change.

Consideration of both the larger issues and specific instances of opportunity and challenge illuminate the new pathways we must pursue.

A CHANGING ENVIRONMENT FOR EDUCATION AND RESEARCH

The end of the Cold War, the stunning advances in information technology, global economic competition, and the changing demography of America are rapidly creating new expectations, responsibilities, and opportunities for institutions of higher education, and especially research universities:

- The military needs of the Cold War era and the culture of superpower competition created a public and political climate of support for advanced education and research. Defense became the dominant driver of high technology and provided an underlying rationale for the support of much basic science as well. The benefits of this support extended far beyond our security, narrowly defined, to build new industries and national capabilities through an enhanced knowledge base and a more highly educated citizenry. This now has changed abruptly. The cold peace that we have won has eroded this supportive climate, and left the compass of national policy spinning, rather than locked onto new directions that would unite, inspire, and advance us.

- In a generation, computers have grown from curious devices to a ubiquitous technology of unprecedented power and influence. Information technology now links us across time and space in a manner that is revolutionizing human organizations. How knowledge is acquired and operated upon, and how work is accomplished in the future are likely to be so influenced by information technology as to be unrecognizable in today’s context.
• We already live in a global society. Most notably, our corporations buy, sell, produce, employ, and compete in countries all over the world. They interact continuously across national, cultural, and linguistic borders. Even so, most American citizens continue to lead rather isolated lives, particularly during their childhood years. Second languages are not acquired, and the experience of living in other countries, or even visiting them on more than a superficial plane, is rare. International leisure travel is beyond the financial grasp of most children as they grow up. Yet these young men and women will have to work in a highly global environment when they reach adulthood.

• The face of America is changing and changing rapidly. Our minority populations will continue their rapid growth in the next generation. We are experiencing immigration from the east and south on a scale comparable to the waves of Europeans coming to our shores early in the century. The range and extent of professional activity and leadership accessible to women continue to expand.

From these changing realities and contexts, a new agenda for universities must emerge – one that will emphasize their contributions to civilian issues: improving health and welfare; creating industries and societies that are sustainable in terms of energy and environment; increasing quality and productivity in both manufacturing and service industries; understanding the origin, development, and reduction of violence; establishing and replenishing our physical and information infrastructures; and preparing students to live, work, and exercise leadership in an increasingly international context.

THE MISSION OF HIGHER EDUCATION

The central mission of universities is to educate students. Drawing on the German model, America added to this mission the generation of new knowledge. In the period since the Second World War, we continued this evolution to create the uniquely American research university. At their best, these institutions are communities of learning that respect the intrinsic value of new knowledge and understanding, while at the same time emphasize the importance of interacting with and influencing the world beyond campus boundaries. The nature and raison d'etre of these communities are generally well understood and held in common by their members.

The external perception of the universities' mission, however, is increasingly unclear. For many decades both the public and governments held a fairly common understanding that the underlying role of education in America at all levels was to prepare citizens to operate a democracy. This essentially Jeffersonian view has served the nation well, bringing a commitment to education for all citizens, and a healthy mingling of practical education with humanistic, artistic, and scholarly endeavors. It provided the fertile soil that supported the growth of the post-Civil War land-grant universities and the post-World War II research universities. There now is a great sense of turbulence and uncertainty that suggests that some new educational form will emerge in this immediate post-Cold War era. At the least, the social contract among the taxpaying public, and the private, governmental, and academic sectors will be rewritten.
UNIVERSITIES AND THE FEDERAL GOVERNMENT

Nearly 50 years ago a confident America, seeking to build a strong future for its citizens, established an approach to advancing science, technology, and education that is unique in the world. The government, noting the critical role that university faculty and researchers had played in World War II, turned to the universities to conduct the basic research that would undergird our national goals.

For half a century, federal agencies have funded research and graduate education programs that have been uncommonly successful. Federally supported university research has generated essential components of our technology base, produced new generations of scientists and engineers, and driven the economy in important ways.

Federal spending at research universities was viewed as an essential investment in the future. The economic payback on this investment is hard to determine, but in recent decades, the economic analysis of University of Pennsylvania economist Edwin Mansfield suggests that the annual rate of return on investment in academic research is on the order of 25 – 30 percent. The Congressional Budget Office reviewed this analysis and concurred with this estimate of the remarkable rate of economic payback to the country on its investment in academic research. Nonetheless, the public and the Congress now increasingly question the value, priority, and relevance of this investment. The sense of partnership between government and universities has decayed dramatically.

Establishing a renewed partnership and common vision requires that we look forward, not backward, and face the challenges of a new era. It requires that we set a good balance between immediate national needs and the long-term good of the country. It also requires that we recognize the increasing scale, cost, and complexity of research. But above all, it requires that we establish a sense of common purpose.

A key mechanism for setting the tone of the evolving relationship and nature of federal support of higher education is the establishment of national research policy. Once the relatively clear domain of the executive branch, such policy is increasingly set in Congress through the appropriation process. This makes the job of establishing purpose and commitment much more difficult.

America knows better than any other nation how to do research, but we have lost our common understanding of why to do research.

Our national R&D pendulum swings fast and wide. We commit the nation to advance fundamental physics by constructing the Superconducting Supercollider, spend $2 billion, and then decide not to do it after all. We declare that industrial policy or even technology policy is verboten, then within a couple of years we commit to a national clean car initiative organized by the Department of Commerce. National laboratories, mostly dedicated to weapons production and accustomed to noncompetitive, steady funding, suddenly aim to become adept at assisting industry. And in industry itself, central research laboratories with a strong commitment to basic research have for the most part been transformed into organizations with entirely different missions.
These swings are manifestations of the vagaries of our political system, but they also are indicative of an unstable search for policy in a time of fundamental change. Synergy and common understanding among the universities, the federal government, and industry have been lost. They must be regained.

**Balancing the Short and Long Views**

A major issue for the future of research universities will be the emerging federal view of the proper balance between clearly applicable research and the fundamental pursuit of the unknown. Ignoring fundamental research is just another way of living for the short term at the expense of future generations. How to develop this balance and how to continually renew and draw fully on the talents and expertise of our faculties are the essence of a set of questions that must be addressed by those who establish policy in America for science, technology, and research. In the final analysis, establishing congruence between the driving passions of researchers and societal goals is the central issue of science and technology policy.

The last several years have seen considerable angst and strain among universities, the federal government, and industry regarding the nation's research and development profile, policies, and in particular the role of academia. We have begun to think about research in new and often unfamiliar terms. Some would turn rapidly to highly applied research, redirect the activities of scientists and engineers, and increasingly foreordain the specific directions of scientific research and technological investigation. After all, the argument goes — with considerable validity — Congress and the American taxpayer expect a strong return on their investment, preferably in the form of measurable improvements in our economy, and especially in high-wage employment.

Such arguments and actions greatly worry those who understand the dynamics of science, its unpredictability, and its dependence on curiosity and sudden insight as well as on hard work and a supportive environment. In order to prosper, and to provide maximum long-term benefit to society, science needs flexibility, continuous support, and passion.

These conditions are endangered by the current state of federal/academic relations. The past few years have seen a continuing attempt on the part of both Congress and the Administration to shift substantial portions of the cost of conducting university research away from the federal sponsors of that research. Rather than reimbursing universities for the full cost of the research conducted on our campuses, the government has expected the universities to shoulder more of those costs. This means using our tuition, gift, and endowment revenues to cover unreimbursed costs of federally sponsored research. At MIT, such changes already account for a recurring, annual shortfall of $10 million in federal reimbursement of actual and legitimate costs of research. There is a continual stream of further actions to arbitrarily cap reimbursement or otherwise undermine the support of our nation's research.

For example, this year the House of Representatives passed an appropriations bill that would have instantaneously decreased Department of Defense support of research at universities to 40 percent of its current level. The potential damage of this was imponderable. This is the primary source of federal support of engineering graduate education and research in the United States. It supports over 75 percent of
all electrical engineering research on our campuses, and it accounts for approximately 50 percent of research in other critical fields such as mechanical engineering, computer science, materials science and engineering. Only at the eleventh hour during a Senate-House conference was this cut modified, but we still were left with a destructive 14 percent cut – a $200 million reduction in funding for DOD sponsored research on the nation's campuses.

Such instances have caused the university community to work with great intensity to promote understanding of the issues by members of Congress and their staffs. We have enlisted the help of leaders of American industry to explain the disastrous consequences to our economy and competitiveness. In the process of fighting each of these difficult, defensive political battles, the universities have had to divert enormous time and effort from our primary mission of education and research.

We are in the midst of an increasingly vicious cycle of Congressional attack followed by intense defensive efforts by universities to create withdrawal or compromise. As we try to make our case, however, we are increasingly chided for acting like lobbyists, a role with which we are distinctly uncomfortable. Yet when push comes to shove, a common complaint by members of the Congress when an issue arises is that we haven't been paying enough attention to them. This is not a stable way to conduct federal policy. This is a time of both change and financial stress that calls for reasoned development of policy.

UNIVERSITIES AND INDUSTRY

Just as we are in the midst of change in our relations with the federal government, so too are relations with private industry changing. Much of this is driven by the rapid changes in industry itself. The end of the Cold War, combined with the incredible rate at which electronic communication is expanding, and the irreversible globalization of competitive businesses have led to radical transformations of industries and organizations. This is accelerated by the expanding knowledge base that is giving rise to entire new industries such as biotechnology. Work is being accomplished in new ways as products are completely defined digitally before they exist physically, as so-called agile organizations are formed by electronic links among component groups throughout a company, or more likely among large and small groups spread around the world. Although the emerging forms of organization are not yet clear, it is certain that students need different preparation to enter this new work environment.

For the research universities, this situation is full of opportunity and responsibility, but also of danger. I believe that the opportunity and responsibility greatly outweigh the danger, particularly for MIT, which was founded to create a strong, even unique, relationship with industry. The opportunities and responsibilities are clear: an exciting new, intellectual, and educational agenda needs to be forged, especially in engineering and management. The dangers are equally clear: universities run the risk of assuming an overly utilitarian role, and the crucial openness of academic dialogue could be lost through ill-conceived policies regarding intellectual properties and dissemination of new knowledge.

The history of interaction of industry and academia has been mixed, and there have been major roadblocks of cultural differences and arrogance on both sides. We too
often have passed as ships in the night, not really listening to or understanding each other. This is changing. Industrial issues have become intellectually challenging and exciting from the perspective of faculty and students, and, indeed, we need each other as never before.

The intellectual agenda of MIT and some other universities is evolving as new technological issues arise and as we attempt to understand and define new organizational structures. This can only be done by increasing the breadth and depth of dialogue and partnership with private industry, as well as with government. It can only be done if it is strongly supported both financially and intellectually.

**Potential Clashes between Industrial and Academic Values**

We must take great care as we develop new relations with industry, however, that universities not assume a posture that is too utilitarian. In time this would erode their intellectual independence and their ability to serve as objective critics of society. Indeed, there is a paradox in that it is this very independence and objectivity that usually attract industry to work jointly with academia. As we work together in areas such as the environment, energy, telecommunications, and productivity that have policy implications, we must maintain our independence and objectivity. Thus it is in the best interests of both parties that these matters be addressed carefully and resolved.

Another area of potential clashes of industrial and academic values is intellectual property. Universities hold dear their role in discovering and disseminating knowledge. The underlying assumption is that what we do on our campuses is, or should be, of general value to society and should be shared openly to advance humankind. In addition, many universities maintain unrealistic expectations about "striking it rich" through patent royalties and have tended to be overly protective and difficult when it comes to negotiating sponsored research agreements.

Companies, on the other hand, must compete to create value for their customers and financial gain for their stockholders. Therefore they have an interest in holding closely both the knowledge and techniques that give them a competitive advantage. Patent ownership is a tool for protection of their competitive advantage, for maximizing profits by charging for their use, and for avoiding having to pay royalties to others, including universities.

Why has the matter of proprietary knowledge and patent rights become so controversial? First, there are simplistic understandings of what constitutes technology transfer. This has been particularly visible in debates about university interactions with non-US based companies, where it sometimes is assumed that university scientists and engineers generate highly specific devices and ideas that are the immediate "silver bullets" to create consumer products. Although this may be the case in rare instances, it generally is not. In fact, the most important mechanism for technology transfer from universities, and from companies for that matter, is educated and trained people and their broad-based knowledge and know-how.

Second, the time from fundamental discovery to commercialization has decreased dramatically in many fields, and margins of competitive advantage have become very small and fleeting in many fast-paced industries. It also must be recognized that views on this topic seem to vary, largely based on the maturity and scale of the
industry in question. It also generally is the case that discussions with industry
leaders at the highest ranks within corporations seem to be much more flexible than
with those at the operating level who are involved with making project level
decisions.

MIT's current approach to patents is designed to encourage the transfer of technology
to the private sector. This requires an ability to negotiate with industrial sponsors as
equals, best accomplished in our view, by ownership of intellectual properties
produced by campus researchers coupled with flexibility in reaching agreements with
sponsors about licenses.

A final debate should be noted that may indeed prove to be much more complex than
those discussed above - intellectual properties and copyrights in the emerging world
of digital information systems. The knowledge base used for both scholarly and
commercial pursuits is rapidly becoming stored, disseminated, and operated upon in
digital form. Knowledge bases are increasingly created electronically by individuals
and organizations dispersed both geographically and temporally. This raises very
fundamental and difficult questions about ownership and access to knowledge. It is
made worse because our system of copyrights and patents is an archaic one based on
a world in which the printed page was the only information carrier. When coupled
with the regulatory environment within which the rapidly emerging worldwide
information highway and distributed digital library must operate, we will face some
very interesting questions, that again may place universities and industries in
debate.

RESPONSES TO A NEW ERA

In an era in which economic, political, demographic, scientific, and technological
changes occur at breathtaking speed, there are extraordinary opportunities for
industry, government, and academia to regenerate themselves and to forge new
alliances. Indeed, industry already is changing very rapidly; our federal
government's R&D policy will change; and higher education, especially in
engineering and management, must change.

Industry's Response
As American industry has faced challenges of unprecedented intensity to its ability to
compete in the world marketplace, the goal of its R&D establishment has changed to
concentration on relevance to commercial interests and reduction of product cycle
times. The great industrial research laboratories that primarily conducted relatively
basic research in areas of long-range potential to their companies have nearly
disappeared. Industrial R&D groups must now clearly and continuously justify their
importance to the company's business. This has had some salutary effects. After
radical restructuring and clarification of missions, many industrial R&D groups are
showing renewed vigor, are developing vastly improved interdisciplinary capabilities
to improve goods and services, and are stimulating new commercial successes.

These changes create two potential problems. The first is a lack of investment in
mid- to long-term research. The second is the danger that communication across
company and campus boundaries will be choked off.
Today's technological advances are generally very complex, and we must have a broad understanding of how the entire system of research and development evolves and advances. A company that makes power generation equipment, to pick an example, depends upon an extended R&D infrastructure that, over time, has produced knowledge of combustion and fluid mechanics, computers, and software for simulation and design, advanced materials, and many other techniques and entities largely developed under sponsorship by the government, often with long-range military needs in mind, or in industrial research laboratories of a type that hardly exist any longer. Much of the nation's traditional strength in industrial research that is relatively fundamental, yet has a strong potential for industrial applicability, is rapidly eroding, replaced with narrowly-defined, company-specific R&D. Despite the improvements in competitiveness of individual companies that their transformed R&D organizations have greatly aided, we must recognize that a system that emphasizes short-term gain, promotes local secretiveness, and discourages open interaction across company and university boundaries, will lose the momentum needed for the long-run good of the nation.

As their economic positions improve, corporations will need to increase the fraction of earnings devoted to research, and they will need to direct some of this into mid-to-long-term research. Once industries become productive and cost competitive, and achieve high quality levels through concentration on process, they will enter a next round of competition that will require new levels of innovation and design. This, in turn, requires generation of, or access to, advancing scientific and technological knowledge. Companies have an obligation to produce some of this new knowledge, but also to participate in a national, or perhaps global, R&D infrastructure. They no longer can take for granted either the extended system of federally sponsored, university-based research or the major industrial research laboratories that have provided such advances for the last four decades. It is essential that we experiment with substantial new forms of R&D partnerships among industry, universities, and government. Joint projects, new forms of consortia, industrial laboratories adjacent to campuses, and new research agendas will be required to create a new R&D infrastructure for the post-Cold War era.

As industry establishes new research and educational partnerships with universities, technology transfer from universities to the private sector will continue to be an important concept. This has an honorable genesis in the land-grant universities that created agricultural experiment stations and county agent systems for the development and dissemination of applicable scientific knowledge to the nation's farmers. Openness of agricultural research results was central to this system, but contemporary technology-based partnerships pose significant issues about dissemination of research results.

We must carefully consider the matter of patents and openness. The situation requires thought from a systemic and long-range perspective. What, in the long run, will serve all parties well? Because of the need to maintain the extended R&D infrastructure, the issue of rebalancing competition and cooperation lies at the center of consideration of policy toward patents and proprietary research on campuses. We must minimize secretiveness and overly protective patent policies on the part of companies sponsoring research or otherwise working in partnership with research universities.
Government’s Response

Federal policy must respond in two ways. First, it must assure strong funding for truly fundamental research. This is the long term investment, the patient capital that is essential for the benefit of our children and their children. Second, the government should work in partnership with private industry and academia to identify those areas of technological advancement that are most critical to the well-being of the nation. Once identified, broad goals should be set for them. Tasks must not be dictated in detail, but general strategic directions should be set and wide bands or pathways in which research scientists and engineers can pursue their efforts should be defined. There must be room for the free market of ideas.

In order to be a great nation, we must press onward with our commitment to support fundamental research and the people and institutions that enable it. History shows that advancement of knowledge, beyond its intrinsic value, does indeed lead to advances in health, productivity, learning, and quality of life. It is the foundation on which progress is built. If we in America do not pursue fundamental research along uncharted pathways, others will. Indeed, others should. All nations that aspire to excellence and advancement of the human condition should strongly support basic science.

Yet, we also know the facts. There are identifiable, strategically important areas of science and technology that we must master and advance in order to improve or even maintain our industrial competitiveness. This is true, notwithstanding the fact that with greater freedom, scientists and engineers will discover and invent new, as yet undreamed of and even more important technologies.

It would be suicidal to dictate what all researchers should work on and to set simplistic goals for immediate commercial application of all that they do. It will not work. The futility of state planning brought down the Berlin Wall. But, it is entirely appropriate to foster a new commitment to solving the problems of our era – the civilian concerns that the end of the Cold War frees us to address, and that are essential to the well-being of the next generation. This is challenging and exciting. Appropriate areas are rather easy to define: the environment, energy, transportation, our telecommunications and computing infrastructure, and more livable cities, to name a few.

Research Universities’ Response

The necessary response of universities lies partly in their research programs, but even more importantly in education per se. We must strive to be sure that research universities fulfill their promise as learning environments remarkably well suited to the coming era – in which undergraduates, graduate students, and faculty alike share in the discipline, joy, and continual renewal of original research and scholarship. Our research orientation enables us to lead the way in education, because society will ask much more of our graduates than that they know what others have accomplished in the past. If our students are to reach their full potential to contribute to society and, just as importantly, to enjoy fully the beauty and the adventure of creating and understanding, we have to teach them how to advance knowledge.

In addition, the increasing complexity of tasks that will face our graduates means that we must better prepare our students to understand how to draw on knowledge
from many different disciplines, how to contribute as members of teams as well as individuals, and how to communicate with members of the public, government or business community, as well as with their professional colleagues.

Beyond that, we must take greater responsibility for helping students to develop broader world views and the expertise required to live and work in a more global context. This responsibility extends beyond the classroom and laboratory to the nature of our student body and faculty itself. We must be unflinching in our efforts to be accessible to and inclusive of all of our talented young men and women. Indeed, most of us can point with considerable pride to the diversity of our undergraduate student bodies, accomplished through a great deal of hard work in the 1970's and 80's. Yet we still have much to do to build the diversity of our graduate student populations and our faculties, and to successfully draw together the increasingly diverse talents and cultural perspectives of our faculty and students around a common set of basic values and purposes.

This need to explore and understand "real world" complexities and organizations requires that we must work more in partnership with industry. Specifically, we need to bring engineering and management closer together in the education of industrial and societal leaders. Academia and industry should work together to bring about a greater common understanding of industry's needs and the university's educational role in fulfilling them. Of course, we should discount ideas that are relevant only to the current moment and keep focused on the long-term good.

Researchers and engineers from industry and university faculty should spend significant time in each other's domains in order to undertake cooperative projects, both basic and applied. This could become a remarkably effective mechanism for technology transfer. There are substantial roadblocks to doing so. Faculty feel that they cannot leave their posts for a year because they will not be able to maintain the momentum of their research projects. Outstanding engineers in industry believe that they will fall off their career path if they leave their current responsibilities for a year. Surely this problem is solvable if companies and government funding agencies would make a concerted effort to enable such exchanges. Let's get serious about this. Every other country in the world seems to encourage and reward first-rate engineers and scientists for spending time as visiting researchers in American universities.

Another further step is for colleagues in university and industry to work closely together to design the engineering and management education programs of the future and to discuss research agendas. MIT has taken a number of steps to ensure a good dialogue among faculty and industrial leaders and to complement the ongoing activities of our Industrial Liaison Program and various research consortia. In September of 1993, MIT held, in conjunction with the World Economic Forum, an Industry Summit that attracted over 800 high-level leaders of industry and government from around the nation and world to discuss issues facing industry and to explore solutions to them. In addition, during the past academic year, an Institute Task Force on Industry Linkages has been considering and making recommendations regarding the appropriate relationships between MIT and industry for the coming decade.

At MIT we have a special obligation to educate engineers, managers, and scientists who can lead in this changed milieu. Our greatest challenge in this regard is to
develop in our students the attitudes, as well as the aptitudes, needed to translate new knowledge from research to practical ends.

INVESTING IN THE FUTURE

Knowledge and a population educated and skilled in ways that permit its creative use are the capital resources of the emerging era. Knowledge, not natural resources or geographic location, will determine which nations and societies prosper. Knowledge is distributed throughout organizations and societies; and we must learn to utilize it collectively and effectively. Knowledge will increasingly be gleaned by computer networks from far-flung sources, shaped by collaborative efforts, moderated by information technology. Knowledge can only be generated and wisely used by educated and inspired people. The generation of new knowledge requires commitment to, and investment in, research.

Universities are our primary vehicle for educating talented men and women and for producing new knowledge, insight, and techniques. In order to serve well, universities must balance continuity and change. Continuity of their deeper values, guiding principles, and commitment to intellectual excellence and the life of the mind are essential. Yet so is a willingness to change, experiment, and improve. America's colleges and universities are changing in response to the new era – changing too slowly, perhaps, but profoundly. A walk across MIT's campus will disclose a student body radically different from that of 20 years ago, one increasingly rich in its racial and cultural makeup, reminding us again that our country is changing rapidly and that we still are a nation of immigrants, as we always have been.

Our curricula are shifting to meet new needs, challenges, and opportunities. All MIT students now must learn cellular and molecular biology. Master's-level education in our Schools of Engineering and Management is being altered and integrated. New, international, university/government/industry partnerships are being formed to conduct objective studies of environmental issues and create sound policy alternatives. New programs are emerging – ranging from fundamental studies of mind and memory to new product development and manufacturing. New linkages to industry are forming. Yet much more remains to be done as the intellectual agenda for the post-Cold War era and a new economic citizenship emerge. We have only scratched the surface of using information technology and multimedia to create new and more effective ways of knowing and learning. We have only begun to understand what is required to prepare our students to cooperate and compete across national and cultural boundaries.

Universities like MIT must become more cost effective and improve the quality of all that they do as organizations and learning communities. Many view us as clinging to the past, unwilling to change and improve. We must regain the public trust if we are to realize our aspirations and serve the future as we always have. This requires that we change substantively, becoming organizationally still more lean and effective. We have started to re-engineer many of our administrative and service activities to become more cost effective, productive, and efficient. We must lead in this effort just as we lead intellectually. Only in this way will we remain financially accessible to those we must educate.

But we cannot escape the fact that the nation must continue to invest in its system of higher education and research. The federal government must stop the trend of
shifting the cost of research it sponsors to tuition, gift, and endowment funds. Private industry must work with us, and invest in us, to ensure the health of the nation's research and development by supporting us intellectually and financially in new ways.

The dreams and visions of our institutions and our students will not be fully realized, and the nation and world will not fully benefit from our potential, unless a renewed commitment to education and research is forged and widely held by the public. This is not a matter of luxury – it is a matter of regaining pride and belief in our people and their future.

CHARLES M. VEST
October 1994
There were a number of significant changes within the MIT faculty, administration, and staff this year, several related to the unexpected death in April of Vice President Constantine B. Simonides, who also was secretary of the MIT Corporation.

The death of Mr. Simonides, 59, on April 24, 1994, while playing tennis, stunned and saddened the community. His warmth and humanity, his ebullient personality and his boundless energy made MIT a happier, more satisfying place to work. As secretary of the Institute’s board of trustees, he had been one of four corporate officers of MIT for the past decade. He also served as vice president in the office of the president for 24 years, providing incalculable assistance to four presidents during a period of extraordinary growth and change. In these positions, Mr. Simonides served the Institute’s governing board and MIT as a whole with absolute devotion and loyalty, along with consummate administrative skill. And, always, his greatest talent was his fascination with and insight into people. His responsibilities included personnel, the medical department, public relations, admissions, athletics, career services, and the MIT Press. He also served as the Institute’s equal opportunity officer. In all of these roles, Mr. Simonides helped raise MIT to higher levels of performance, leaving an imprint on the Institute that will serve us well for many, many years into the future.

The Institute is fortunate to have men and women of his caliber to fill leadership roles following his death.

Promoted to vice president were Joan F. Rice, Director of Personnel, as Vice President for Human Resources, and Barbara G. Stowe, Director of Foundation Relations and Development Services, as Vice President for Resource Development. Ms. Rice also became the Institute’s Equal Opportunity Officer. Appointed as Secretary of the Executive Committee of the Corporation, and later elected Secretary and ex-officio member of the Corporation, was Kathryn A. Willmore, who thus becomes one of the Institute’s four corporate officers. She continues as Director of Public Relations Services and Executive Assistant to the President.

In addition, two vice presidents took on new responsibilities. Glenn P. Strehle, Treasurer and Vice President for Resource Development, became Vice President for Finance and Treasurer. James J. Culliton, Vice President for Financial Operations, became Vice President for Administration.

Other significant administrative changes included the appointment of Thomas R. Moebus, Director of the Industrial Liaison Program and Acting Director of Corporate Relations, as Director of Corporate Relations. In the office of Dean for Undergraduate Education and Student Affairs, a number of promotions took place: Travis R. Merritt, to Dean of Undergraduate Academic Affairs; Robert M. Randolph, to Senior Associate Dean; Jacqueline R. Simonis to Associate Dean and Section Head for Counseling Services; Milena M. Levak to Associate Dean and Section Head of the International Students Office; Arnold R. Henderson, to Associate Dean in Counseling Services; Danielle Guichard-Ashbrook to Assistant Dean in the International Students Office; and Debbie H. Shoap to Staff Associate in the UROP office. In addition, Dr. Margaret A. Jablonski joined the staff as Associate Dean and Section Head for Residence and Campus Activities.
Major academic appointments included the selection of Glen L. Urban as Dean of the Sloan School of Management, succeeding Lester C. Thurow. Professor Urban, who was co-director of the International Center for Research on the Management of Technology, is — as described by Provost Mark S. Wrighton — “an excellent leader and manager with a track record of setting ambitious goals and achieving them.”

Professor Stanley Fischer was appointed Head of the Department of Economics, and is now on a leave of absence as First Deputy Managing Director of the International Monetary Fund.

Other academic appointments included: Professor Herbert H. Einstein as Director of the Mining and Minerals Resources Research Institute; Professor Bernard J. Frieden as Associate Dean of the School of Architecture and Planning; Professor James Howe as Head of the Anthropology and Archaeology Section in the Department of Humanities; Professor Mark A. Kastner as Director of the Center for Materials Science and Engineering; Professor Lionel C. Kimerling as Director of the Materials Processing Center; and Professor Thomas W. Eagar as Co-Director of the Leaders for Manufacturing Program.

Stepping down from posts in the academic administration this year were Professor Samuel J. Keyser, returning to research and teaching in the Department of Linguistics and Philosophy after nine years as associate provost, and Otto Piene, retiring after nearly 20 years as director of the Center for Advanced Visual Studies.

Professor Keyser played a critical role in a wide range of educational issues, conflict resolution and new initiatives, particularly in developing programs to build collegiality among faculty, students, and staff.

Professor Emeritus Piene, an internationally respected sculptor known for his majestic sky figures, has been a leading figure in bringing technology into the creative process, in demonstrating the interdependency of art, nature, and science, and in emphasizing the civic and public role of art.

Finally, in an organizational change intended to enhance the already interdisciplinary nature of education and research in brain and cognitive sciences, the Department of Brain and Cognitive Sciences became part of the School of Science. The department has pioneered in uniquely combining the experimental technologies of neurobiology and neuroscience with the theoretical power of artificial intelligence and cognitive science.

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The honors and achievements of MIT faculty and staff are so numerous that I mention only some of the individual efforts and awards which have brought distinction to the Institute.

Phillip A. Sharp, Salvadore E. Luria Professor Biology and Head of the Department of Biology, won the 1993 Nobel Prize in physiology or medicine for work that fundamentally changed scientists' understanding of the structure of genes. He shared the prize with Dr. Richard J. Roberts of New England Biolabs, who independently
came to the same conclusions at approximately the same time. The work has had important implications for the evolution of organisms and the causes of some hereditary diseases and cancers.

Two faculty members were named to high government posts by President Clinton. Sheila E. Widnall, professor in the Department of Aeronautics and Astronautics, became the first woman to head one of the military services when she was appointed Secretary of the Air Force. Professor Widnall, who was associate provost of MIT before going on leave, is one of the world's leading experts in fluid dynamics. Former provost John M. Deutch, already serving in the Department of Defense, was promoted to Deputy Secretary of Defense, the "number two" post in the Pentagon. Five faculty members were elected to the National Academy of Engineering: Paul L. Penfield, Jr., Professor of Electrical Engineering and Head of the Department of Electrical Engineering and Computer Science; Woodie C. Flowers, School of Engineering Professor of Teaching Innovation; John G. Kassakian, Professor of Electrical Engineering and Director of the Laboratory for Electromagnetic and Electronic Systems; James D. Livingston, Senior Lecturer in the Department of Materials Science and Engineering; Gunter Stein, Adjunct Professor of Electrical Engineering and Corporate Fellow and Chief Scientist at Honeywell Systems and Research Center. The elections bring to 97 the number of MIT active and emeriti/ae faculty elected to NAE. Ten MIT alumni/ae were also elected to the Academy this year.

Three faculty members were elected to the National Academy of Sciences: Arnold L. Demain, Professor of Industrial Microbiology in the Department of Biology; David E. Housman, Professor of Biology in the Department of Biology and an associate in neurology and genetics at Massachusetts General Hospital; Julius Rebek Jr., the Camile Dreyfus Professor of Chemistry, Department of Chemistry. Their election brings to 99 the number of MIT faculty members in the NAS. Six alumni were also elected.

The teaching excellence of four professors and their "exemplary and sustained contributions" to undergraduate education were recognized by MIT with their appointments as MacVicar Faculty Fellows. The new fellows are: Richard P. Binzel, Associate Professor of Planetary Sciences in the Department of Earth, Atmospheric, and Planetary Sciences; Gene M. Brown, the Whitehead Professor of Biochemistry; Woodie C. Flowers, the School of Engineering Professor of Teaching Innovation; and Ole S. Madsen, Professor in the Department of Civil and Environmental Engineering.

John H. Harbison, Class of 1949 Professor in the Music and Theater Arts Section, was selected as the 1994-95 recipient of the James R. Killian Jr. Faculty Achievement Award, which recognizes extraordinary professional accomplishments and service to MIT. The selection committee described Professor Harbison as "one of the two or three most important composers in America today."

Martha L. Gray, associate professor in the Department of Electrical Engineering and Computer Science and the Harvard-MIT Division of Health Sciences and Technology, was named the 1994 recipient of the Harold E. Edgerton Faculty Achievement Award, given annually to a junior faculty member in recognition of exceptional teaching, research, and scholarship. The selection committee described Professor Gray as "a fabulous, dedicated, talented, and insightful teacher," and cited her successful integration of quantitative concepts into the teaching of cell pathophysiology.
The Gordon Y Billard Award, which recognizes those who have performed special service of outstanding merit for MIT, went to Doreen Morris, Assistant Provost for Administration, and Episcopal chaplain Reverend Scott Paradise, who retired this year.

Kenneth H. Olsen, MIT alumnus and founder of Digital Equipment Corporation, received the prestigious National Medal of Technology at a White House ceremony.

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The Institute was saddened this year by the deaths of several longtime friends and colleagues, including Constantine Simonides, whose many contributions to the Institute are noted earlier in this report.

President Emeritus Julius A. Stratton, eminent scientist and educator, died on June 22, 1994, at the age of 93. Dr. Stratton was MIT's 11th president from 1959 to 1966 and had been associated with MIT continuously since his enrollment as an undergraduate in 1920. He received the S.B. in electrical engineering in 1923, the S.M. in 1926 and a Ph.D. from the Swiss Federal Institute of Technology in 1928. That same year he became assistant professor at MIT, associate professor in 1935, and full professor in 1941. Much of his research concentrated on the propagation of short waves, and he was the first director of the Research Laboratory of Electronics. In 1949 Dr. Stratton was appointed MIT's first provost and received an additional concurrent appointment as vice president in 1951. He was named chancellor in 1956, became acting president in 1957, and president in 1959. Dr. Stratton's years as a faculty member and administrator were marked by a deep concern for the individual and a genuine interest in students and their problems. He led major efforts in curriculum revision and in the development of the residential program. He championed the importance of science at all levels of education and the need for humanistic studies in undergraduate scientific and engineering curricula. When Dr. Stratton reached mandatory retirement age in 1966, he was elected a life member of the MIT Corporation.

Lawrence B. Anderson, former dean of the School of Architecture and Planning, died on April 6, 1994, at the age of 87. Professor Anderson, who received a graduate degree in architecture from MIT in 1930, joined the faculty in 1933, became a full professor in 1944, and Head of the Department of Architecture in 1947. He was dean of the School of Architecture and Planning from 1965 until 1972. Under Professor Anderson's stewardship, changes in direction and curriculum were achieved that responded to the needs of architectural education and to the role of the School of Architecture and Planning as part of a technological institution. After his formal retirement, he remained a member of the Council for the Arts. Professor Anderson was co-designer in 1940, with Professor Herbert L. Beckwith, of the Alumni Pool complex, considered one of the first significant modern works in this country.

Nesmith C. Ankeny, professor emeritus of mathematics, died August 4, 1993, at the age of 66. Professor Ankeny did much of his research in analytic number theory, which is concerned with the properties of whole numbers. He also was known for his interest in game theory. He joined the MIT faculty in 1955 and became a full professor in 1964.
Donald J. Atwood, a member of the MIT Corporation, former Deputy Secretary of Defense and former executive of General Motors, died on April 24, 1993, at the age of 69. Mr. Atwood received the S.B. in electrical engineering from MIT in 1948, and the S.M. in 1950, when he joined the technical staff of the Instrumentation Laboratory. In 1952 he left MIT to become treasurer and chief engineer of the Dynatrol Corporation, later acquired by General Motors. Mr. Atwood went on to become vice chairman of the board of General Motors and served in that position until 1989, when he went to the Defense Department.

Vera Ballard, assistant director of the Whitaker College of Health Sciences and Technology, died of cancer on June 17, 1994, at the age of 42. Ms. Ballard began her career at MIT in 1978 in the Personnel Office, where she worked as a personnel officer and administrator. She became administrative officer at Whitaker College in 1983 and assistant director in 1987. She was a member of the MIT Equal Employment Opportunity Committee, the MIT Medical Department Consumer Council, and the National Council of University Research Administrators. In 1984, she received recognition of her contributions to the Institute through a Black Achievers Award.

Pietro Belluschi, dean of the School of Architecture and Planning from 1951 to 1965, and widely-known both as an architect and educator, died on February 14, 1994, at the age of 94. During his tenure as dean, the Ph.D. degree in planning was established and the Joint Center for Urban Studies was founded. Dean Belluschi continued his architectural practice and participated in the design of more than 1,000 buildings, including the Julliard School of Music and Alice Tully Hall in New York City.

Roger G. Burns, professor of mineralogy and geochemistry, died of cancer on January 7, 1994, at the age of 56. Professor Burns joined the faculty at MIT in 1970 as associate professor and within two years was promoted to professor. He was well known for his major role in developing mineral spectroscopy. At MIT his expertise in mineralogy and geochemistry and rapport with students led to innovative research, such as characterizing the formation of manganese-rich minerals on the sea floor, and understanding the mineralogy of the surface of Mars.

Muriel Cooper, professor of interactive media design, died of a heart attack on May 26, 1994, at the age of 68. She came to MIT in 1952 as the director of the Institute’s newly formed Office of Publications, now known as Design Services. After leaving MIT in 1958 to take a Fulbright Scholarship in Milan, she returned to Boston and ran her own graphics studio for several years. In 1967, she joined the MIT Press as its first art director and became widely recognized for her innovations in book design. After seven years at the MIT Press, she started teaching a subject at MIT which looked at graphics in relation to technology. She became assistant professor in 1977, the first graphic designer appointed to the faculty. She was promoted to associate professor in 1981 and professor in 1988. Professor Cooper cofounded and directed MIT’s Visible Language Workshop; her teaching and research focused on how computers can enhance the graphic communication process and how high-quality graphics can improve computer information systems.

James H. Doolittle, MIT alumnus, life member emeritus of the MIT Corporation, pioneer in the science of aviation and record-setting pilot who led the first World War II bombing raid on Japan, died on September 27, 1993, at the age of 96. He was a retired lieutenant general, having begun his military career in the Army Air Corps and
completed it in the US Air Force. When he received the Master of Science and Doctor of Aeronautical Engineering degrees in June of 1925, there were less than 100 people in the world who held comparable advanced degrees. His studies at MIT marked the beginning of a lifelong association with the Institute.

Crawford H. Greenewalt, a member of the MIT Corporation for more than 40 years and president of the DuPont Company from 1948 to 1962, died on September 27, at the age of 91. Mr. Greenewalt, a member of the MIT Class of 1922, became a life member of the Corporation in 1951. Mr. Greenewalt played major roles in the development of nylon and in the birth of DuPont's atomic energy program.

Charles Kingsley, Jr., associate professor emeritus of electrical engineering, died on February 20, 1994, at the age of 89. Professor Kingsley, an authority on rotating machines, magnetic circuits and other power apparatus, received the S.B. and S.M. degrees from MIT in 1927 and 1928. Between 1929 and 1940, when he joined the faculty, he was an instructor in the Department of Electrical Engineering. After his retirement he continued to work on research projects at MIT, including the superconducting generator.

Leo B. Moore, professor emeritus of management at the Sloan School, died August 1, 1993, at the age of 78. He received the S.B. and S.M. from MIT in 1937 and 1939, respectively, and during World War II served as deputy director of intelligence for the US Signal Corps in Europe. He joined the Sloan School faculty in 1951 as an assistant professor, became associate professor in 1959 and professor in 1967. He was an authority on industrial standards engineering as well as organizational and personnel management.

W. Beverly Murphy, life member emeritus of the MIT Corporation and former president and chief executive officer of the Campbell Soup Company, died May 29, 1994, at the age of 86. Mr. Murphy was a special term member of the Corporation from 1961 to 1965 and a life member from 1965 to 1982.

Walle J. H. Nauta, Institute Professor Emeritus and one of the world's leading authorities on the anatomy of the brain, died on March 24, 1994, at the age of 77. Dr. Nauta, one of the founders of the modern field of neuroscience, made singular contributions to the understanding of the structure and connectivity of the brain. One of his foremost accomplishments was the development of techniques that enabled experimenters to trace fiber connections in the brain. He came to MIT in 1964 as a professor of neuroanatomy. In 1973, Dr. Nauta's colleagues at MIT bestowed on him the title of Institute Professor.

Bruno B. Rossi, Institute Professor Emeritus and professor emeritus of physics, died November 21, 1993, at the age of 88. One of the nation's most honored scientists, he played a leading role in the study of cosmic rays and in the development of space physics. He was largely responsible for starting X-ray astronomy, as well as the study of interplanetary plasma. As a member of the Space Science Board of the National Academy of Sciences, he contributed to the formulation of public policy in the scientific exploration of space. He became a professor of physics at MIT in 1946 and an Institute Professor in 1966.

Gregory Smith, Life Member Emeritus of the MIT Corporation, died on January 25, 1994, at the age of 86. Mr. Smith, who retired as president of the Eastman Gelatin
Corporation in 1972, spent a major part of his retirement at MIT as an advocate for the Undergraduate Research Opportunities Program, working with faculty members and industry to find ways to involve students in substantive research. He received the S.B. and S.M. degrees from MIT in 1930 and 1931.

Herbert H. Uhlig, professor emeritus of metallurgy and a pioneering researcher into the corrosion of metals, died on July 3, 1993, at the age of 86. He received his Ph.D. from MIT in 1932, later became a research associate at the Institute, and in 1946 became an associate professor and the Director of the Corrosion Laboratory. In 1953 he was promoted to full professor. He coauthored nearly 200 scientific and technical papers dealing with corrosion. In 1982, the Corrosion Laboratory at MIT was dedicated in his honor and renamed “The H. H. Uhlig Corrosion Laboratory.”

Theodore Wood, Jr., professor emeritus of literature and American studies, died August 7, 1993, at the age of 79. Professor Wood, who taught at MIT for more than 45 years, specialized in American literature, culture and folklore. He also was well-known as a guitarist and folksinger, and appeared regularly as a performer and interviewer on television. After serving as a part-time instructor, he joined the MIT faculty in 1952 and became a professor in 1972.
REGISTRATION

In 1993-94 student enrollment was 9,790, compared with 9,798 in 1992-93. There were 4,509 undergraduates (4,520 the previous year) and 5,281 graduate students (5,278 the previous year). The international student population was 2,196, representing eight percent of the undergraduate and 35 percent of the graduate populations. These students were citizens of 101 countries. (Students with permanent residence status are included with US citizens.)

In 1993-94, there were 2,757 women students (1,528 undergraduate and 1,229 graduate) at the Institute, compared with 2,722 (1,506 undergraduate and 1,216 graduate) in 1992-93. In September 1993, 369 first-year women entered MIT, representing 34 percent of the freshman class of 1,081 students.

In 1993-94, there were, as self-reported by students, 2,417 minority students (1,905 undergraduate and 512 graduate) at the Institute, compared with 2,271 (1,806 undergraduate and 465 graduate) in 1992-93. Minority students included 346 African Americans (non-Hispanic), 41 Native Americans, 478 Hispanic Americans, and 1,552 Asian Americans. The first-year class entering in September 1993 included 502 minority students, representing 46 percent of the class.

DEGREES AWARDED

Degrees awarded by the Institute in 1993-94 included 1,092 bachelor's degrees, 1,230 master's degrees, 31 engineer's degrees, and 516 doctoral degrees – a total of 2,869 (compared with 2,812 in 1992-93).

STUDENT FINANCIAL AID

During the academic year 1993-94, an improving economy helped reduce the rate at which the demand for financial aid continued to climb, while increased contributions to the scholarship endowment and income from outside scholarship support helped to meet the need for grant funds. A total of 2,660 students who demonstrated need for assistance (54 percent of the enrollment) received $32,861,000 in grant aid and $12,677,000 in student loans from all sources. The total, $45,538,000 represents a 6 percent increase in aid compared to last year.

Grant assistance to undergraduates was provided by $9,724,000 in income from the scholarship endowment, by $1,064,000 in current gifts, by $3,740,000 in federal grants (including ROTC scholarships), and by $2,810,000 in direct grants from non-federal outside sources to needy students. In addition, $15,523,000 in scholarships from MIT's unrestricted funds was provided to undergraduates, inclusive of the special program of scholarship aid to needy minority group students which represented $505,000, and the MIT Opportunity Awards which accounted for $794,000. An additional 468 students received grants irrespective of need from outside agencies, totaling $2,187,000. The undergraduate scholarship endowment was increased by the addition of $4,788,675 in new funds. These new contributions increased the endowment for scholarships by 6 percent to $86,981,404.
Loans totaling $12,677,000 were made to undergraduates, a 14 percent increase from last year. (This increase reflects the 34 percent increase in Federal Stafford Loans resulting from expanded eligibility criteria and increased loan limits under this program.) Of the total loans made, $1,324,000 came from the Technology Loan Fund, $3,032,000 came from the Federal Perkins Loan Program, and $8,321,000 came from the state-administered Stafford Guaranteed Student Loan Program and other outside sources.

Graduate students obtained $2,120,000 from the Technology Loan Fund. In addition, $236,000 was loaned by MIT under the Federal Stafford Guaranteed Student Loan Program. The total, $2,356,000, is a 3 percent decrease from last year's level. Graduate students obtained $3,585,000 from outside sources under the Federal Stafford Program, 14 percent more than last year and $1,843,000 from Federal Supplemental Student Loans and other outside sources. Graduate students also received $11,000 in Perkins Loan funds. The total, $7,795,000 is an increase of 5 percent over last year.

The total of loans made to undergraduate and graduate students was $20,472,000, an 11 percent increase over last year.

The improving economy helped to slow the rate of increase in the number of needy undergraduate students and the average need. The number of needy students remained almost the same as last year, increasing by only 8 students to 2,660. The average need for this population increased by 6 percent to $18,761. In the aggregate, the financial aid program required $23,241,000 from needy students' family resources and provided $49,907,000 in aid dollars including work programs. As in past years, the aid program provided more than two-thirds of needy students' total costs.

CAREER SERVICES AND PREPROFESSIONAL ADVISING

In spite of some significant industries doing very little hiring – among them aerospace, automobiles, oil, and chemicals – recruiting at the Institute continued to hold up well. Three hundred and ninety-three separate employing organizations conducted interviews in the central careers office, up from 382 the previous year. As in 1992-93, firms selling non-material products and services were responsible for much of the recruiting activity. This year almost 42 percent of the organizations recruiting on campus were software firms, consulting firms of various sorts, or banks. The financial industry was second only to civilian electronics in the number of organizations conducting interviews. It is too soon to say whether the service sector attracted a comparable percentage of the students entering employment, but student interest ran high, at all degree levels. Students completing degrees in the natural sciences and engineering no longer see themselves as necessarily committed to careers in technology.

Salaries showed very little change from 1992-93, except at the master's level in some fields.

The number of MIT applicants to medical school continued to increase. One hundred and sixty students and alumni/ae used the services of the Institute in filing their applications, up from 143 in 1992-93. The Association of American Medical Colleges reports that there were as many 201 MIT candidates in all. The last time MIT
candidates applied in such numbers was 20 years ago, in the aftermath of the Vietnam War.

GIFTS

Gifts, grants, and bequests to MIT from private donors in 1993-94 totaled $94.6 million. This amount includes cash, securities, and real estate gifts totaling $86.8 million, and $7.8 million in support through the Industrial Liaison Program. In addition, gifts in kind, mostly of equipment, totaled $6.1 million. The gifts reported by the Alumni Fund were $23.0 million, a new record.

Payments on pledges and significant new commitments continued to be received following the end of the successful Campaign for the future on June 30, 1992. Major efforts are continuing to increase endowment for student financial aid, faculty support, academic initiatives, new and renovated space, and unrestricted funds.

FINANCES

As reported by the Vice President for Finance and Treasurer, the total financial operations of the Institute, including sponsored research, amounted to $1.14 billion – an increase of 0.5 percent from 1992-93. Education and general expenses – excluding the direct expenses of departmental and interdepartmental research and the Lincoln Laboratory – amounted to $560.7 million during 1993-94 compared with $542.1 million in 1992-93. The direct expenses of departmental and interdepartmental sponsored research on campus increased from $259.2 million to $263.3 million, while direct expenses of the Lincoln Laboratory sponsored research decreased from $332.6 million to $315.5 million. Current revenues used to meet the Institute's operating expenses totaled $1.13 billion, augmented by $6.2 million in current gifts, $1.9 million of other fund balances, and $4.3 million of funds functioning as endowment.

At the end of the 1994 fiscal year, the Institute's investments, excluding retirement funds, student notes receivable, and amounts due from educational plant, had a book value of $1.8 billion and a market value of $2.15 billion compared to last year's book value of $1.6 billion and market value of $2.13 billion.

PHYSICAL PLANT and CAMPUS ENVIRONMENT

Concern for the safety of those who work, study, and reside on the MIT campus continued to be a high priority. New campus lighting along Memorial Drive and in Killian Court was installed for improved visibility, card readers were put in place at the Westgate and Vassar Street parking areas for tighter access control, major safety and security-related improvements to the Albany Street Garage were initiated, and card access control replaced exterior door key control in most of our dormitories.

During the year, many renovations and physical improvements were undertaken across the campus. Construction began on the Tang Management Center, and the Cambridge City Council granted permission to construct a pedestrian bridge over Ames Street to connect the Tang Center, when completed, with the Muckley Building (E40). Construction continued on the Cogeneration Plant, with completion projected for late next winter. Major renovation projects were initiated in Building 3 (the Pappalardo Mechanical Engineering Laboratory); Buildings 3, 5, 7, and 10 (Architecture); W2/2A
(conversion to dormitory spaces); W11 (the Religious Center); and the E17 Animal Facility.

Two projects were completed this year, the Biology Building (Building 68) and the CASPAR (Cambridge and Somerville Program for Alcoholism and Drug Abuse Rehabilitation) Emergency Service Center at 240 Albany Street. The Biology Building, a 247,250 square foot facility, is a state-of-the-art building with office space, conference rooms, laboratories, and animal facilities. Ground was broken for the CASPAR Center, a 55-bed rehabilitation facility, in October. Despite difficult winter weather conditions, it was completed and occupied in the late spring.

The Institute purchased a town house at 478 Commonwealth Avenue in Boston for the purpose of providing a chapter house for the MIT Chapter of Alpha Chi Omega Sorority. Renovation commenced immediately upon the closing of the sale, with occupancy anticipated for the start of school in the fall.

A group of individuals, all of whom are involved with the implementation of services in support of persons with disabilities, was convened in order to better coordinate on an ongoing basis the Institute's response to the Americans with Disabilities Act (ADA) and other related issues.
Personnel Changes

CORPORATION

DEATHS
Donald J. Atwood
Member
James H. Doolittle
Life Member, Emeritus
Crawford H. Greenewalt
Life Member, Emeritus
W. B. Murphy
Life Member, Emeritus
Constantine B. Simonides
Secretary
Gregory Smith
Life Member, Emeritus
Julius A. Stratton
Life Member, Emeritus

ELECTIONS
James A. Champy
Member
Alexander V. d’Arbeloff
Life Member
Edie N. Goldenberg
Member
Richard A. Jacobs
Member
Judy C. Lewent
Member
Patrick J. McGovern
Member
A. Neil Pappalardo
Member
Peter M. Saint Germain
Member
Richard P. Simmons
Member
Mark Y. D. Wang
Member

MEMBERS EX-OFFICIO
R. Gary Schweikhardt
President
Alumni Association
Kathryn A. Willmore
Secretary

TERMS EXPIRED
Karen W. Arenson
Member

FACULTY

DEATHS
Nesmith C. Ankeny
Department of Mathematics
Roger G. Burns
Department of Earth, Atmospheric, and Planetary Sciences
Muriel R. Cooper
Media Arts and Sciences Section
Leo B. Moore
Sloan School of Management
Walle Jetze Nauta
Institute Professors
Herbert H. Uhlig
Department of Materials Science and Engineering
Theodore Wood, Jr.
Literature Section

RETIREMENTS
Glenn A. Berchtold
Professor
Department of Chemistry
Donald L. M. Blackmer
Professor
Department of Political Science
Richard L. Cartwright
Professor
Department of Linguistics and Philosophy
Eric J. Dluhosch
Professor
Department of Architecture
Philip B. Herr
Adjunct Professor
Department of Urban Studies and Planning
Sandora C. Howell
Professor
Department of Architecture
Robert S. Kennedy
Professor
Department of Electrical Engineering and Computer Science

RESIGNATIONS

Professor
Chi-Fu Huang
Sloan School of Management
Alexander Keyssar
History Section
Paul R. Krugman
Department of Economics

Associate Professor
Edith K. E. Ackermann
Media Arts and Sciences Section

PROMOTIONS
To Professor
Rodney A. Brooks
Department of Electrical Engineering and Computer Science
Stephen L. Buchwald
Department of Chemistry
Isabelle de Courtivron
Foreign Languages and Literatures Section
J. Brian Evans
Department of Earth, Atmospheric, and Planetary Sciences
Philip M. Gschwend
Department of Civil and Environmental Engineering
Eric Lander
Department of Biology

Assistant Professor
Geoffrey M. Brooke
Sloan School of Management
Lee Krumholz
Department of Materials Science and Engineering
Manuel Oliveria
Department of Civil and Environmental Engineering
Stephan Schrader
Sloan School of Management
Zhengfang Zhou
Department of Mathematics

James W. Axley
Department of Architecture
John M. Graybeal
Department of Physics
Theoharis C. Theoharis
Literature Section
Hae-Seung Lee
Department of Electrical Engineering and Computer Science

Henry S. Marcus
Department of Ocean Engineering

John C. Marshall
Department of Earth, Atmospheric, and Planetary Sciences

Manuel Martinez-Sanchez
Department of Aeronautics and Astronautics

Rodolfo Rosales
Department of Mathematics

Leigh H. Royden
Department of Earth, Atmospheric, and Planetary Sciences

Michael F. Rubner
Department of Materials Science and Engineering

Paul D. Sclavounos
Department of Ocean Engineering

Jeremy C. Stein
Sloan School of Management

Arthur Steinberg
AnthropologyArchaeology Program

Miriganka Sur
Department of Brain and Cognitive Sciences

Peter Szolovits
Department of Electrical Engineering and Computer Science

John N. Tsitsiklis
Department of Electrical Engineering and Computer Science

James M. Utterback
Sloan School of Management

To Associate Professor

V. Michael Bove
Media Arts and Sciences Section

Benjamin H. Buchloh
Department of Architecture

Peggy Cobe
Department of Materials Science and Engineering

Glorianna Davenport
Media Arts and Sciences Section

Steven D. Eppinger
Sloan School of Management

Ezra Getzler
Department of Mathematics

Karen K. Gleason
Department of Chemical Engineering

Rebecca M. Henderson
Sloan School of Management

Dorothy Hosler
AnthropologyArchaeology Program

Henry Jenkins
Literature Section

Lily E. Kay
Program in Science, Technology, and Society

Peter T. Lansbury
Department of Chemistry

Richard M. Locke
Sloan School of Management

Martin Marks
Music and Theater Arts Section

David McAllester
Department of Electrical Engineering and Computer Science

Richard G. Milner
Department of Physics

Leslie K. Norford
Department of Architecture

Leo Osgood
Athletic Department

Gregory M. Papadopoulos
Department of Electrical Engineering and Computer Science

Michael A. Rappa
Sloan School of Management

James B. Rebitzer
Sloan School of Management

Steven H. Strogatz
Department of Mathematics

Halston W. Taylor
Athletic Department

Andrew Whittle
Department of Civil and Environmental Engineering

Krzysztof Wodiczko
Department of Architecture

Jacquelyn C. Yanch
Department of Nuclear Engineering

CHANGES OF APPOINTMENT

Thomas J. Allen
Howard W. Johnson Professor of Management and MacVian Faculty Fellow
Sloan School of Management

Anuradha M. Annaswamy
Flowers Career Development Assistant Professor
Department of Mechanical Engineering

Abhijit Banerjee
Pentti J. K. Kouri Career Development Associate Professor
Department of Economics

Ella L. Bell
Assistant Professor of Organizational Studies
Sloan School of Management

Sibel Bozdogan
Ford International Career Development Assistant Professor
Department of Architecture

S. Lael Brainard
Mitsubishi Career Development Assistant Professor
Sloan School of Management

Kenneth S. Breuer
Harold E. Edgerton Career Development Assistant Professor
Department of Aeronautics and Astronautics

Maria C. Deyst, Jr.
Professor

Charles Stark Draper
Development Assistant Professor

Eric Feron
University Career Development Assistant Professor
Sloan School of Management

Maria Flowers
Pappalardo Professor of Mechanical Engineering
Department of Mechanical Engineering

Michael P. Cleary
Adjunct Professor
Department of Mechanical Engineering

Fernando J. Corbato
Ford Professor of Engineering
Department of Electrical Engineering and Computer Science

Christopher C. Cummins
Assistant Professor
Department of Chemistry

John J. Deyst, Jr.
Jerome C. Hunsaker Professor
Department of Aeronautics and Astronautics

Thomas W. Eager
Co-Director, Leaders for Manufacturing Program and POSCO Professor
Department of Materials Science and Engineering

Elazer R. Edelman
Assistant Professor of Health Sciences and Technology
Harvard-MIT Division of Health Sciences and Technology

Eliath Eltahir
Assistant Professor
Department of Civil and Environmental Engineering

Steven D. Eppinger
Nanyang Technological University Career Development Associate Professor
Sloan School of Management

Joel P. Clark
Development Assistant Professor

Eric Feron
Charles Stark Draper Career Development Assistant Professor

Stanley Fischer
Department Head and Elizabeth and James Killian Professor of Economics

Woodie Flowers
Pappalardo Professor of Mechanical Engineering
Department of Mechanical Engineering

Maria Flytzani-Stephanopoulos
Visiting Professor
Department of Chemical Engineering
Personnel Changes

NEW APPOINTMENTS

Professor

Anita Desai
Professor
Program in Writing and Humanistic Studies

F. Dale Morgan
Professor
Department of Earth, Atmospheric, and Planetary Sciences

Subra Suresh
Richard P. Simmons
Professor of Metallurgy
Department of Materials Science and Engineering

Associate Professor

Abhijit Banerjee
Department of Economics

Ian Hunter
Department of Mechanical Engineering

Jaime Peraire
Associate Professor
Department of Aeronautics and Astronautics

Jeffrey S. Reed
Associate Professor
Department of Ocean Engineering

Andrew M. Scott
Associate Professor
Department of Architecture

Assistant Professor

K. Daron Acemoglu
Department of Economics

Ron Adiel
Assistant Professor
Sloan School of Management

Stephen Ansolabehere
Assistant Professor
Department of Political Science

John G. Brison, II
Assistant Professor
Department of Mechanical Engineering

Dora L. Costa
Assistant Professor
Department of Economics

Sergey Fomin
Assistant Professor
Department of Mathematics

Bernard J. Frieden
Associate Dean, School of Architecture and Planning and Ford International Professor
Department of Urban Studies and Planning

Victor Guillemin
Norbert Wiener Professor
Department of Mathematics

Timothy G. Gutzwiller
Director and Professor Laboratory for Manufacturing and Productivity

John V. Guttag
Associate Department Head and Professor
Department of Electrical Engineering and Computer Science

Michael J. Hawley
X-Consortium Assistant Professor of Computer Science and Media Technology
Department of Electrical Engineering and Computer Science

Paul M. Healy
Deputy Dean and Nanyang Technological University Professor of Management
Sloan School of Management

James Howe
Professor and Head Anthropology Archaeology Program

Paul L. Joakow
Associate Department Head and Professor
Department of Economics

Marc A. Kastner
Director, Center for Materials Science and Engineering and Donner Professor in Physics Center for Materials Science and Engineering

Langley C. Keyes, Jr.
Ford Urban Professor
Department of Urban Studies and Planning

Lionel C. Kimerling
Director, Materials Processing Center and Thomas Lord Professor of Materials Science and Engineering
Department of Materials Science and Engineering

Leslie A. Kolodziejski
Esther and Harold E. Edgerton Associate Professor
Department of Electrical Engineering and Computer Science

Michael Kremer
Assistant Professor
Department of Economics

Steven B. Leeb
Carl Richard Soderberg Assistant Professor in Power Engineering Department of Electrical Engineering and Computer Science

Jun Liu
Assistant Professor
Department of Biology

Ole S. Madsen
MacVicar Faculty Fellow
Department of Civil and Environmental Engineering

Pauline Maier
Professor and Acting Head History Section

Chiang C. Mei
Edmond K. Turner Professor of Civil and Environmental Engineering

Travis R. Merritt
Dean for Undergraduate Academic Affairs
Undergraduate Education and Student Affairs

Shigeru Miyagawa
Professor and Acting Head Foreign Languages and Literatures Section

Francois M. M. Morel
Edmund K. Turner Professor of Civil and Environmental Engineering

Vicki Norberg-Bohm
Assistant Professor
Department of Urban Studies and Planning

Wanda J. Orlikowski
Gordon Y. Billard Career Development Assistant Professor
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James D. Paduano
Carl Richard Soderberg Assistant Professor in Power Engineering Department of Aeronautics and Astronautics

Georgia Perakis
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Sloan School of Management

Gill A. Pratt
Assistant Professor of Electrical Engineering and Computer Science
Department of Electrical Engineering and Computer Science

Michael F. Rubner
TDK Professor of Materials Science and Engineering Department of Materials Science and Engineering

Alexander H. Slocum d’Arbeloff Career Development Associate Professor
Sloan School of Management

Lester C. Thurow
Jerome and Dorothy Langley Career Professor of Management and Economics
Sloan School of Management

Thanasis Triantafillou
Visiting Assistant Professor
Department of Civil and Environmental Engineering

Marcie J. Tyre
J. Spencer Standish Career Development Assistant Professor
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Clarence G. Williams
Adjunct Professor
Department of Urban Studies and Planning

August F. Witt
Ford Professor of Engineering Department of Materials Science and Engineering

Gregory W. Wornell
ITT Career Development Assistant Professor of Electrical Engineering Department of Electrical Engineering and Computer Science

Alwyn Young
Ford International Career Development Assistant Professor
Sloan School of Management
Personnel Changes

Ellen Dunham-Jones
Assistant Professor
Department of Architecture

Alan Edelman
Assistant Professor
Department of Mathematics

Zaichun (Frank) Feng
Assistant Professor
Department of Mechanical Engineering

Eric Feron
Assistant Professor
Department of Aeronautics and Astronautics

Kai von Fintel
Assistant Professor
Department of Linguistics and Philosophy

Gregory C. Fu
Assistant Professor
Department of Chemistry

Edward A. F. Gibson
Assistant Professor
Department of Brain and Cognitive Sciences

David A. Gonzales
Assistant Professor
Department of Aeronautics and Astronautics

Michael J. Hawley
Assistant Professor
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Kristina E. Hill
Assistant Professor
Department of Urban Studies and Planning

Paul E. Laibinis
Assistant Professor
Department of Chemical Engineering

Jacqueline Lees
Assistant Professor
Department of Biology

Bernard C. Lesieutre
Assistant Professor
Department of Electrical Engineering and Computer Science

Dava J. Newman
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Ann M. Pendleton-Jullian
Assistant Professor
Department of Architecture

Thomas Piketty
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Department of Economics

Qing Shen
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Department of Economics

Peter K. Sogner
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Department of Biology

Charles C. Steidel
Assistant Professor
Department of Physics

David L. Trumper
Assistant Professor
Department of Mechanical Engineering

Lucy Assali
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Materials Processing Center

Steve B. Borah
Visiting Professor
Air Force Aerospace Studies

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Barbara E. Bund
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Douglas Burbank
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Buckner M. Creel, IV
Visiting Professor
Military Science

Andrea A. di Sesa
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Media Arts and Sciences Section

Richard D. Diamond
Visiting Professor
Center for Cancer Research

Francisco Fernandez-Gonzalez
Visiting Professor
Department of Ocean Engineering

William F. Fitzgerald
Visiting Professor
Department of Civil and Environmental Engineering

Robert J. Fogelin
Visiting Professor
Department of Linguistics and Philosophy

Larry Friedlander
Visiting Professor
Literature Section

Roger Huang
Visiting Professor
Sloan School of Management

Carlos E. Kenig
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Department of Mathematics

Anthony W. Knapp
Visiting Professor
Department of Mathematics

James Knowles
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Department of Mechanical Engineering

Robert E. Kottwitz
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Department of Chemical Engineering

Shlomo Maial
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Nicola Makarov
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Department of Mathematics

Kazutaka Makino
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Robert Narendra
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Department of Mechanical Engineering

Minoru Oda
Visiting Professor
Department of Physics

Mary B. Parlee
Visiting Professor
School of Humanities and Social Science

Juan R. Sammartín
Visiting Professor
Department of Aeronautics and Astronautics

Nobou Sano
Visiting Professor
Department of Materials Science and Engineering

Tetsuo Shoji
Visiting Professor
Department of Nuclear Engineering

Carlos T. Simpson
Visiting Professor
Department of Mathematics

John M. Stopford
Visiting Professor
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Pin Tong
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Department of Civil and Environmental Engineering

Sten Wandel
Visiting Professor
Center for Transportation Studies

Timothy Williamson
Visiting Professor
Department of Linguistics and Philosophy

Wayne L. Worrell
Visiting Professor
Department of Materials Science and Engineering

Visiting Associate Professor

Andreas N. Alexandrou
Visiting Associate Professor
Materials Processing Center

Steven J. Davis
Visiting Associate Professor
Department of Economics

Thierry de Duve
Visiting Associate Professor
Department of Architecture

Tae Hyun Kim
Visiting Associate Professor
Center for Transportation Studies

Toshihiro Kubota
Visiting Associate Professor
Media Arts and Sciences Section

Kunwoo Lee
Visiting Associate Professor
Department of Mechanical Engineering

Oliver G. McGee
Visiting Associate Professor
Department of Aeronautics and Astronautics
David Neelin
Visiting Associate Professor
Department of Earth, Atmospheric, and Planetary Sciences

Adeboyejo A. Oni
Visiting Associate Professor
Department of Management

Attilio Petruccioli
Visiting Associate Professor
Department of Architecture

Bruno Pfister
Visiting Associate Professor
Department of Architecture

Robin Ann Prager
Visiting Assistant Professor
Sloan School of Management

Akshay Rao
Visiting Associate Professor
Sloan School of Management

Cynthia F. Simmons
Visiting Associate Professor
Foreign Languages and Literatures Section

Tetsuo Yai
Visiting Associate Professor
Department of Ocean Engineering

Visiting Assistant Professor

Takako Aikawa
Visiting Assistant Professor
Foreign Languages and Literatures Section

Howyda Al-Harithy
Visiting Assistant Professor
Department of Architecture

Sara Beckman
Visiting Assistant Professor
Sloan School of Management

Bettina Brandt
Visiting Assistant Professor
Foreign Languages and Literatures Section

Michael Byron
Visiting Assistant Professor
Department of Architecture

Mohammad Durali
Visiting Assistant Professor
Department of Aeronautics and Astronautics

Steven Imrich
Visiting Assistant Professor
Department of Architecture

Mina Marefat
Visiting Assistant Professor
Department of Architecture

Don O. May
Visiting Assistant Professor
Sloan School of Management

Matthew Rabin
Visiting Assistant Professor
Department of Economics

Lars A. Stole
Visiting Assistant Professor
Department of Economics

ADMINISTRATION

DEATHS

Vera J. Ballard
Assistant Director
Whitaker College of Health Sciences and Technology

James d'Innocenzo
Manager
Division of Comparative Medicine

Harold W. Roberts
Route Supervisor
Superintendent's Office

Beverly A. Robinson
Administrative Assistant
Operations and Systems

Constantine B. Simonides
Vice President
Office of the President

RETIEMENTS

Roderick R. Arthur
Assistant Director
Athletic Department

Brian J. Clifton
Administrative Staff
Lincoln Laboratory

Michael F. Collins
Supervisor,
Mechanical Services
Physical Plant

Joseph R. Cullinan
Administrator
Credit Union

Josephine M. DiCicco
Records Manager
Sloan School of Management

Pasquale F. Ferro
Supervisor,
Mechanical Services
Lincoln Laboratory

Jack H. Fraley
Director, Office of Registration and Student Financial Services
Vice President for Financial Operations

William M. Hall, Jr.
Administrative Staff
Lincoln Laboratory

Sally H. Hansen
Personnel Officer
Personnel Office

Jean H. Hill
Administrative Staff
Lincoln Laboratory

George E. Hosker
House Manager
Housing

James J. Maloney
Assistant Supervisor
Physical Plant

Winifred T. McDonough
Recording Secretary
Treasurer's Office

Stanley Miller
Assistant to the Comptroller
Comptroller's Accounting Office

Elizabeth C. Nelligan
Senior Accounting Officer
Lincoln Fiscal Office

Richard J. Noyes
Associate Director
Center for Advanced Engineering Study

Kevin J. O'Toole
Director, Internship Program
Department of Electrical Engineering and Computer Science

Albert K. Paone
Acting Director
Graphic Arts

John Prialaga
House Manager
Housing

Joseph M. Salvatore
Staff Architect/
Senior Project Manager
Physical Plant

Leo J. Sullivan
Administrative Staff
Lincoln Laboratory

Frank M. Vecchia
Administrative Staff
Lincoln Laboratory

Walter R. Vecchia
Administrative Staff
Lincoln Laboratory

Elizabeth J. Whittaker
Associate Secretary
Chairman of the Corporation

RESIGNATIONS

Marylene Altieri
Librarian
Libraries

Darlene M. Anderson
Auditor
Audit Division

Patrice A. Baer
Journals Assistant
Production Manager
MIT Press

Scott Barnard
Fiscal Officer
Computing Support Services

Stephanie K. Bartling
Staff Assistant
Undergraduate Education and Student Affairs

Sally Leah Beerbower
Staff Administrator
Distributed Computing and Network Services

Cassandra N. Blattner
Manager,
Sustaining Fellows Program
Office of Individual Giving

Marilyn L. Bodnar
Manager of Administration and Section Head
Undergraduate Education and Student Affairs

Judith L. Boudreau
Program Manager
Sloan School of Management

Leo R. Braginsky
Analyst Programmer
Distributed Computing and Network Services

D. Scott Brandt
Associate Head Librarian
Libraries

Linda R. Brewster
Executive Director
Office of the Vice President
<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valerie A. Bryce</td>
<td>Assistant to the Bursar</td>
</tr>
<tr>
<td>Office of the Bursar</td>
<td></td>
</tr>
<tr>
<td>David E. Charron</td>
<td>Technology Licensing Officer</td>
</tr>
<tr>
<td>Technology Licensing Office</td>
<td></td>
</tr>
<tr>
<td>Ellen M. Comare</td>
<td>Assistant to the Bursar</td>
</tr>
<tr>
<td>Office of the Bursar</td>
<td></td>
</tr>
<tr>
<td>Jill E. Davidson</td>
<td>Research Analyst</td>
</tr>
<tr>
<td>Office of School</td>
<td></td>
</tr>
<tr>
<td>Development Services</td>
<td></td>
</tr>
<tr>
<td>Frances Davis</td>
<td>Fiscal Officer</td>
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<tr>
<td>Telecommunications Systems</td>
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<tr>
<td>Jacques Victor Dejean</td>
<td>Systems Programmer</td>
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<tr>
<td>Operations and Systems</td>
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<tr>
<td>Peter J. Delaney</td>
<td>Manager, Operations</td>
</tr>
<tr>
<td>Telecommunications Systems</td>
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<tr>
<td>Christina D. Demello</td>
<td>Consultant</td>
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<tr>
<td>Computing Support Services</td>
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<tr>
<td>Michael R. Dempsey</td>
<td>Senior Major Gifts Officer</td>
</tr>
<tr>
<td>Office of Individual Giving</td>
<td></td>
</tr>
<tr>
<td>Alfred R. Doig, Jr.</td>
<td>Assistant Dean</td>
</tr>
<tr>
<td>School of Engineering</td>
<td></td>
</tr>
<tr>
<td>Anthony Dovidio</td>
<td>Database Analyst</td>
</tr>
<tr>
<td>Administrative Systems</td>
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<td>Development</td>
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<tr>
<td>Colette P. Fearnley</td>
<td>Voice Mail Administrator</td>
</tr>
<tr>
<td>Telecommunications Systems</td>
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<tr>
<td>Steven L. Foley</td>
<td>Consultant</td>
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<tr>
<td>Operations and Systems</td>
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<tr>
<td>Barbara Y. Fortin</td>
<td>Route Supervisor</td>
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<td>Physical Plant</td>
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<tr>
<td>Myron L. Freeman</td>
<td>Systems Support Consultant</td>
</tr>
<tr>
<td>Department of Electrical Engineering and Computer Science</td>
<td></td>
</tr>
<tr>
<td>Kathryn L. Gandek-Tighe</td>
<td>Associate Director</td>
</tr>
<tr>
<td>Office of School Development Services</td>
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<tr>
<td>Dawn E. Geary</td>
<td>Coordinator</td>
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<tr>
<td>Computing Support Services</td>
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<tr>
<td>Peter P. Gil</td>
<td>Director of External Relations</td>
</tr>
<tr>
<td>Sloan School of Management</td>
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<tr>
<td>Kathleen A. Green</td>
<td>Associate Head Librarian</td>
</tr>
<tr>
<td>Libraries</td>
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<tr>
<td>John B. Hammond, III</td>
<td>Associate Director</td>
</tr>
<tr>
<td>Admissions Office</td>
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<tr>
<td>Joseph L. Hammond</td>
<td>Analyst Programmer</td>
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<td>Administrative Systems</td>
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<td>Development</td>
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<tr>
<td>Leonard J. Hausman</td>
<td>Director, Taiwan Program</td>
</tr>
<tr>
<td>Sloan School of Management</td>
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<tr>
<td>Peter D. Henderson</td>
<td>Consultant</td>
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<tr>
<td>Computing Support Services</td>
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<tr>
<td>Shelley A. Hiatt</td>
<td>Research Analyst</td>
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<tr>
<td>Vice President for</td>
<td></td>
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<tr>
<td>Resource Development</td>
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<tr>
<td>Shawn W. Hill</td>
<td>Network Engineer</td>
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<tr>
<td>Medical Department</td>
<td></td>
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<tr>
<td>Linda Antone Holmes</td>
<td>Consultant</td>
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<tr>
<td>Distributed Computing</td>
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<td>and Network Services</td>
<td></td>
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<tr>
<td>Maureen A. Horgan</td>
<td>Program Administrator</td>
</tr>
<tr>
<td>Undergraduate Education and Student Affairs</td>
<td></td>
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<tr>
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<td>Derrick Kong</td>
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<td>David Marsh</td>
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<tr>
<td>Francis X. McCauley</td>
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<td>Scott McGuire</td>
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<tr>
<td>Julie Shipp Mitchell</td>
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<td>Gjyl Mustafa</td>
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<td>Campus Activities Complex</td>
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<td>T. Ann Newman</td>
<td>Space Administrator</td>
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<td>Gail B. Tetrault</td>
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<td>Rebecca Lynn Robins</td>
<td>Supervisor, Technical Processing Services</td>
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<td>Kathryn J. Rose</td>
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<td>Jane R. Snyder</td>
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<td>Ravi Sompalli</td>
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<td>Victoria A. Stettner</td>
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<tr>
<td>James Wolken</td>
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<tr>
<td>Bonnie M. Wong</td>
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<td>Maryam Afshar</td>
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<td>Lawrence Abeln</td>
<td>Director of Master's Alumni Relations</td>
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<td>William H. Ames, Jr.</td>
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<td>Judith A. de Oraan</td>
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Director of New Business
Maria P. Liteplo
Development
Sunshine Lin
Analyst Programmer
Administrative Systems
Development
Maria P. Liteplo
Director of New Business
Development
Industrial Liaison Program
Jennifer Lu
Analyst Programmer
Administrative Systems
Development
Maria C. Lucas
Accounting Analyst
Sloan School of Management
Robert E. Mahoney
Consultant
Distributed Computing and Network Services
Claire Mak
Database Analyst
Administrative Systems Development
Walter J. Mansell
Manager, Operations
Telecommunications Systems
Elizabeth M. Martin
Program Manager
Sloan School of Management
Karon S. McCollin
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Audit Division
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MIT Press
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Lori B. Zetlin
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CHANGES OF APPOINTMENT
Irene T. Abrams
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Safety Office
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Leaders for Manufacturing Program

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Alumni Association

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Program in Writing and Humanistic Studies

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Research and Systems

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Producer  
Center for Advanced  
Engineering Study

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List Visual Arts Center

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Software Acquisition  
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Academic Computing  
Services

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Operations and Systems

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Literature Section

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Records and Administration  
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and Student Affairs

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and Section Head  
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and Student Affairs

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Auditor  
Audit Division

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Fiscal Officer  
Department of Materials  
Science and Engineering

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Administrative Systems  
Development

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Libraries

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Systems Programmer  
Distributed Computing  
and Network Services

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and Student Affairs

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Department of Urban Studies  
and Planning

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Assistant Manager  
Computing Support Services

John S. Wilson  
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Development Services  
and Associate Director  
of Foundation Relations  
Vice President for  
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Mitchell P. Wolf  
Supervisor,  
Customer Services  
Telecommunications Systems

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The academic year 1993-1994 has been a year of intense activity in several areas of my responsibility, and this report covers the highlights. Other key issues are elaborated in the separate reports to the President provided by those who report directly to me. 1993-1994 is the second year of three where we have focused the planning and budgeting process on attempting to reduce the rate of growth in expenditures, and we have also launched our "reengineering" efforts. The financial constraints have dominated thinking, but it is important to note that significant new initiatives are being supported, and we are sustaining a strong rate of academic renewal through aggressive recruiting of new faculty. The Institute is also committing resources for the future in a number of major projects to enhance facilities for instruction and research. The Institute continues to receive superlative rankings of its academic programs, and continued commitment to addressing the rate of growth of expenses while investing prudently in new initiatives and facilities will secure a leadership role for MIT in the future.

One of MIT's highlights for the year was the victory over the Department of Justice in the dispute over our policies regarding the use of financial aid resources. The settlement allows us to sustain our policy of merit-based, need-blind admissions and to distribute our financial aid resources solely on the basis of need. Moreover, the commitment to meet the full need of students admitted to MIT reinforces our resolve to serve the most outstanding students regardless of their financial resources. This policy is a costly one in financial terms, but is one that has enriched our institution with a diverse student body.

Perhaps no individual was more instrumental in reaching the accord with the Department of Justice than the late Constantine B. Simonides, Vice President and Secretary of the Corporation. Constantine's sudden passing in April, 1994 saddened the entire community and left a large void in the administration. We have lost a great MIT contributor and friend and will miss his leadership.

The appointments of Vice Presidents Joan Rice and Barbara Stowe, for Human Resources and Resource Development, respectively, the election of Kathryn Willmore as Secretary of the Corporation, and the realignment of responsibilities of Vice Presidents James Culliton and Glenn Strehle have strengthened the administration and the academic enterprise will be well-served by these key leaders.

ACADEMIC PERSONNEL

1993-1994 was Dean Glen Urban's first as Dean of the Sloan School of Management, and he has been effective in executing his responsibilities. His five year plan is one which involves substantial repositioning of the Sloan School with the aim of educating 21st century business leaders. We have developed a new cooperative financial arrangement which will contribute to developing the proper incentives for education and research involving Sloan faculty.

Professor Robert L. Jaffe completed his first year as Chair of the Faculty. He has been effective in focusing attention on issues related to retirement and has contributed to building stronger faculty-administration interaction in connection with the reengineering effort.

Near the end of the academic year Associate Provost Samuel J. Keyser announced his resignation effective June 30, 1994 to return to teaching and scholarship as Peter de Florez Professor in the Department of Linguistics and Philosophy. Jay served both me and my predecessor, John M. Deutch, with devotion and responsibility. He achieved a great deal during his nine years as Associate Provost, strengthening our education programs, building collegiality among faculty and students, and in developing programs to eliminate harassment. His leadership on matters related to addressing harassment problems and other personnel conflicts has been extraordinary during the
past several years, and his effective effort in this regard represents an enormous contribution to MIT. Selection of a new Associate Provost and some realignment of responsibilities is anticipated during the Summer of 1994.

At the conclusion of the academic year Mr. Jay Lucker, Director of Libraries, announced his intention to retire from the Institute at the end of the Summer of 1995. A process will commence in the Fall of 1994 to identify Mr. Lucker's successor.

ACADEMIC HIGHLIGHTS

**Biology.** One of the highlights of the academic enterprise was the announcement of Professor Phillip A. Sharp as co-recipient of the 1993 Nobel Prize in Medicine or Physiology. Dr. Sharp serves as Salvador Luria Professor and Head of the Department of Biology. Recognition of his work reinvigorated the community and reminds us all of the extraordinary strength of our faculty and students.

The new core requirement in biology has been well-received and has sparked interest in the discipline. Offering biology as a core requirement has required that additional resources be directed to support this new requirement.

Building 68 was essentially completed in the Spring of 1994, and the move of faculty and their research groups into the new facility has gone well. The building is to be formally dedicated in the Fall after the October 7, 1994 meeting of the MIT Corporation.

**Brain and Cognitive Sciences.** The Department of Brain and Cognitive Sciences moved administratively from Whitaker College of Health Sciences and Technology to the School of Science. This move should enhance the career development of junior faculty and lead to stronger educational programs of importance for our undergraduates.

**Center for Learning and Memory.** A joint initiative of the Department of Brain and Cognitive Sciences and the Department of Biology has led to the establishment of the Center for Learning and Memory. Professor Susumu Tonegawa has been selected as the founding director, and the Fairchild Foundation has provided substantial initial support for this exciting new program of research and education.

**Visit of Salman Rushdie.** The Program in Writing and Humanistic Studies, headed by Professor Alan Lightman, invited Salman Rushdie to the MIT campus. Mr. Rushdie engaged an audience who had come to hear Susan Sontag. Ms. Sontag introduced our special surprise guest to an astonished and large audience, and then Mr. Rushdie read from some of his works. I was privileged to award Mr. Rushdie an honorary visiting professorship on behalf of MIT.

**Engineering/Sloan Educational Initiative.** The School of Engineering and the Sloan School of Management have taken steps to begin planning additional cooperative educational programs. The initial emphasis is likely to be on a masters program focused on design activities and involving substantial interaction with industry.

**Center for Materials Research in Archaeology and Ethnology.** Considerable debate surrounded my decision to terminate funding for the Center for Materials Research in Archaeology and Ethnology. Serious shortcomings in the process used to come to the decision were identified by a faculty committee chaired by Professor Peter Diamond. I acknowledged these shortcomings and continue to work both with Professor Lechtman and Professor Hosler to work toward a suitable framework within which they can pursue their scholarly and educational interests.
International Programs. Numerous new international initiatives are being explored. We have concluded a cooperative program with the Catalan government for support of Catalan post-doctoral fellows at MIT in areas such as materials, biotechnology, environment, and design. I am leading discussions to launch an international partnership devoted to addressing environmental problems by engaging academic institutions in Asia and Europe. The specific research programs are being developed by members of the Council on Global Environment. The School of Architecture and Planning and the Sloan School of Management are exploring opportunities for partnership in China. The Department of Civil and Environmental Engineering has advanced a proposal to work cooperatively with the province of Mendoza in Argentina. Many other faculty-driven initiatives are afoot, and it can be anticipated that the new Associate Provost will have responsibility for better coordinating our international education and research programs.

Karl Taylor Compton Lecturer. The Office of the Provost has revitalized the Compton Lectureship during 1993-1994 by having Dr. John Armstrong, Vice President of IBM (retired), as the lecturer. Dr. Armstrong's presentations focused on the role of industrial research and development, and his interaction with faculty and students was very well received.

FACILITIES

In addition to the completion of the biology building (Building 68) noted above, there are a number of other projects underway of importance to the future leadership position of MIT. Some of the projects underway or completed include:

- The Jack C. Tang Center for Management Education is underway and will provide new teaching facilities for the Sloan School; the facility will be finished prior to September, 1995.

- Building 11, formerly housing the Center for Visual Studies, has been renovated and provides space for the chaplaincy, ultimately releasing space for undergraduate dormitories.

- Classrooms 3-133, 10-280, 4-364, 5-232, 5-234, and 1-242 have been renovated or have had renovations initiated during 1993-1994.

- Spaces in the main group for the Department of Architecture's Design Studios of the Future are being renovated.

- Plans are being finalized for the complete renovation of Buildings 16 (Dorrance) and 56 (Whitaker) now that the biology building is complete. These renovations will allow the removal of Building 20, in order to provide a site for a modern education and research facility.

- A cogeneration facility (natural gas as energy source) and upgrades in the electric system are slated to be completed early in calendar year 1995. The system will generate most of the MIT electricity needs (about 90%), all of our steam needs, and the efficiency will have the favorable effects of lowering costs of utilities and reducing environmental emissions. The upgrades in the electricity system will have the effect of improving reliability.

- Lincoln Laboratory's new ~500,000 square foot "South Laboratory" building will be completed in late 1994 or early 1995. The facility allows Lincoln to consolidate its activities and withdraw from leased facilities in the vicinity of Lincoln Laboratory.
DIVERSITY

We continue efforts to diversify the faculty with respect to better representation among women and minority groups. MIT is fortunate to have attracted Professor Alice Amsden to MIT to join our Department of Urban Studies and Planning. She is now the holder of the Ellen Swallow Richards Professorship.

Two of our faculty, Professors Evelynn Hammonds and Robin Kilson were the key individuals in bringing to MIT the Conference on Black Women in the Academy. This event focused attention on the issues faced by black women, and other minorities, in pursuing a career in academia. Opportunities for meeting each other and for networking to build careers of black women emerged and will be important at MIT and other academic institutions.

We were fortunate to have Mrs. Coretta Scott King as the keynote speaker at our Martin Luther King celebration this year. We announced our establishment of the Robert Taylor Professorship during the Martin Luther King celebration, recognizing the extraordinary accomplishments of African Americans—Mr. Taylor was MIT’s first African American graduate in 1892 who went on to a distinguished career in architecture. It is our hope to appoint a distinguished individual to hold this professorship with the next year.

The Department of Labor has been working with MIT to work toward full participation of women and members of minority groups as employees at MIT. The emphasis on the degree of "utilization" by the Department of Labor may have the unfortunate consequence of bringing about complacency among those charged to aggressively seek to appoint women and members of minority groups, because the concept of degree of utilization links MIT employment to the size of the available pool of qualified candidates. MIT cannot rest on the statistics regarding degree of utilization, and we must work toward building the size and quality of the available candidates for employment at academic institutions. I have been working with Dr. Clarence Williams to develop a better understanding of the issues we face in recruiting a more diverse faculty for departments having large undergraduate enrollment. I have also asked Ms. J. J. Jackson to serve as a Special Assistant to me to assist in developing resources for recruiting and retaining minority faculty.

INDUSTRIAL RELATIONSHIPS

MIT is seeking new ways of serving industry’s needs. A task force dealing with this matter is being led by Professor Merton Flemings, and will issue a final report regarding MIT’s industrial linkages in 1994-1995. MIT’s relationships with industry have historically been quite strong, and MIT has been pathbreaking among American universities in developing such interactions. During the past year the support from industry has been about $100 million, including about $60 million in sponsored research. Enhancing MIT’s effective programs of education and research in the future will likely depend on strengthening the engagement with industry.

Two important aspects of industrial relationships during 1993-1994 are especially noteworthy. First, together with the World Economic Forum and Harvard University, MIT hosted the Industry Summit involving the world’s industry leaders and many government officials from around the world. MIT faculty played a key role in defining a program attracting large participation among the world’s industry and government leaders. Second, Amgen, a leading biotechnology company, entered into an agreement with MIT to sponsor research over a ten-year period. The expectation is that the research relationship will be principally with the Department of Biology and with the Department of Brain and Cognitive Sciences with total support of at least $30 million over the ten year period. In recognition of the special relationship between MIT and Amgen, MIT established the Amgen Professorship and appointed Professor Susumu Tonegawa to be the inaugural chairholder. The Amgen/MIT partnership is a model of a mutually rewarding relationship bringing benefit to both organizations and recognizing the distinctive role of each.
With the increasing importance of economic relevance as a criterion in government-sponsored programs, MIT can look forward to building on its remarkable record of industrial interaction. However, greater success in this arena hinges on enhancing responsiveness to industry needs, and the initiatives of the School of Engineering and the Sloan School of Management are especially promising in this regard.

ACKNOWLEDGMENTS

It is a privilege to serve as Provost. To do so in an era of change and financial constraint brings frustration, but also the opportunity to make an important contribution. Many people are working effectively in a cooperative spirit, and I am appreciative of the support of the members of Academic Council with whom I have been working most closely. I am also grateful for the continuing support of the staff support in the Office of the Provost. The excellent work of Ms. Doreen Morris, Assistant Provost for Administration, was recognized in May, 1994 with the Billard Award---richly deserved recognition of extraordinary contributions. I also extend my thanks and appreciation to Ms. Mary Calderazzo, Ms. Christine Graves, and Ms. Laurie Scheffler for their support and effective efforts during this past year. Finally, I wish to acknowledge the personal appreciation I have for the work that Associate Provost Samuel J. Keyser has done for me and for the Institute during my tenure as Provost. His sensitivity, responsiveness to need, and his good humor have enhanced life at the Institute.

Mark S. Wrighton, Provost
MISSION STATEMENT

The Center for Educational Computing Initiatives (CECI) was created in July, 1991 to advance the state-of-the-art and state-of-the-practice in the use of computation and communication technologies in education. The concept of a permanent, interdepartmental research center at MIT that would focus on educational applications of computing was one of the recommendations of the Committee on Academic Computing in the 90's chaired by the late Dean Margaret Macvicar. The creation of CECI, reporting directly to the Provost, and the migration of the operating responsibility for Project Athena to MIT Information Systems were the two major strategic decisions made by the Institute as Project Athena neared its June, 1991 ending date.

In brief, CECI's mission is as follows:

- to undertake research in the application of computer and communications technologies directed towards the goal of improving the effectiveness and productivity of learning and education.

Implicit in this mission statement is the hypothesis that new technologies can improve the quality of education in many areas and that a sustained research focus on such uses of technology will, over time, yield such improvements. An interdepartmental, MIT-wide center such as CECI is essential because such research does not fit well within traditional departmental organizational structures.

MAJOR INITIATIVES

Projects in CECI focus on the three following areas:

- *enabling technologies* - the development of technologies that enable educational applications, including authoring systems, toolkits or libraries of computer code that make the creation of effective computer applications easier and less expensive;
- *creation of applications* - the authoring of new educational applications of computation and computer technologies;
- *evaluation* - studies of how various uses of computer technology affect education, particularly the extent to which innovations in computer applications improve the quality of education.

Some of the major initiatives already begun or in planning are described below.

AthenaMuse: A Multimedia Authoring Environment

During Project Athena, a small group of researchers developed a research prototype of a multimedia authoring system which has come to be called AthenaMuse. This system had many innovative features but was limited in its portability, maintainability and adaptability to new media types. CECI is developing a completely new generation of multimedia authoring software, called AthenaMuse 2, with the following goals:

- To build a suite of highly interactive, visual, and user friendly multimedia editors that support all phases of the creation of multimedia applications. The goal is to provide a set of tools for multimedia applications that can be used by subject experts who are not programmers.
- To develop an improved multimedia runtime environment for the presentation of multimedia documents and interactive applications in a distributed network environment as well as in stand-alone modes.
- To provide independent object libraries that will facilitate the introduction of new multimedia modules and will allow the combination of multimedia components with other software technologies such as three-dimensional rendering, an object oriented database and natural language analysis.
- To define a platform-independent language to describe multimedia applications. The software will provide a low level structured application interchange format that will allow a multimedia application authored on one computer system to run on another that may have very different media peripherals and screen resolution. Versions of AthenaMuse are currently being implemented for Unix (using the MIT-developed X Window System), Microsoft Windows (both NT and Version 3.1), and Macintosh System 7.
- To create content-rich applications that span a wide range of educational areas, including in-class instruction, tutorials, museum collections and library applications.
This initiative continues MIT's leadership in multimedia authoring environments for educational applications and the development of applications themselves. The software development is being undertaken by an industrially-sponsored research and development consortium. This group, called the AthenaMuse Software Consortium, includes both MIT sponsored research staff and full-time industrial visitors. It builds directly on the extensive work on multimedia computing done in Project Athena's Visual Computing Group.

The AthenaMuse Software Consortium currently has 20 sponsors representing corporations, government organizations and universities in Europe, Japan, Canada, South America and the United States. The Consortium's total funding this academic year included $835,000 in direct support and an additional $225,000 consisting of grants of hardware or software.

An alpha test version of AthenaMuse 2.0 was released to the members of the AthenaMuse Software Consortium in April, 1994. Versions with new features will be released approximately every six months for a year.

Environmental Education

Environmental education is an area in which computer and communication technologies have enormous potential. This is in part because environmental studies are typically multidisciplinary in nature, making them a fertile area for tools that allow sharing of different expertise. In addition, learning about the environment can be aided by giving students access to visual images of remote locations (as in studies of the Antarctic ozone hole), providing them with a wide range of data (as in studies of ocean currents or global warming), or providing them with sophisticated simulation tools that allow them to trace the complex economic and social effects of environmental decisions (as in the regulation of CFC's or shifts in automotive pollution control standards). All of these aids can be provided by the technologies at the center of CECI's research interests.

CECI recently completed a project with the Rene Dubos Center for Human Environments, an environmental education group in New York City, on the first of what we expect to be a series of multimedia computer applications targeted to middle school students. The planning of this series and the first application have been funded by United Technologies. We are continuing to raise funding from private donors and corporations to implement the series. The faculty of the MIT Program in Environmental Engineering, Education and Research (PEEER) directed by Prof. David Marks will provide technical advice to the entire series.

CECI is also working with the Prof. Dennis McLaughlin of the Department of Civil and Environmental Engineering on extensions to an computer application on groundwater pollution that is now in use in courses at MIT. This core of this application is a simulation of a contaminant plume. Students can take remedial actions such as pumping contaminated water from wells, treating it, and injecting the treated water into other wells. Costs are assigned to these various actions, encouraging students to think through which measures are likely to be most cost-effective.

Multimedia Exposition on Prof. Harold Edgerton

In collaboration with the MIT Museum and the George Eastman House International Museum of Photography, we are developing two distinct computer-based applications that capture the ideas, art and technology developed by Prof. Harold ("Doc") Edgerton. Doc Edgerton's work includes the development of stroboscopic photography and many of the technologies involved in side-scanning sonar. This project is funded by the Harold E. Edgerton Trust.

The first of the computer applications will be used as part of a traveling, international museum exhibit being created by the George Eastman House. Unlike many earlier Edgerton exhibits, this one will focus not only on the artistic contributions of Edgerton's important stop-action photographs, but also on the experimental apparatus he created in "Strobe Alley". The computer application will explore the many aspects of Doc’s life and times, including his work as an artist, scientist, engineer, celebrity and explorer.

The second computer application is intended for use in middle schools. It will include curriculum materials, still images, video and educational exercises both on the computer and with "hands-on" kits. Through this combination of traditional and new media, we hope to convey a sense of how Doc Edgerton solved real problems, and to empower the student to explore some of the ideas which Edgerton pioneered.

The third component of the project is the creation of a database application for the MIT Museum. This innovative system will allow anyone connected to the Internet to access digitized versions of the important photographs created by Doc Edgerton that will be stored in an innovative database managed by the MIT Museum. Access through the Internet World Wide Web (using
the Mosaic browser software developed at the National Center for Supercomputer Applications) is already being tested. We expect this entire system to be the basis for future digital versions of collections at the MIT Museum.

Media Literacy

CECI is collaborating with Universidad Nacional de Educacion A Distancia in Madrid and the Downs Media Education Center in New Mexico to create a series of multimedia applications for Media Literacy. The applications would use materials (e.g., 'The Image', 'The Moving Image', 'The Sound Image', 'Newspapers', 'Photography', 'The Comic', etc.) already produced by the Universidad Nacional de Educacion A Distancia, which describe basic concepts and skills used for producing and interpreting media images, together with newly acquired materials from international sources for cross-cultural analysis. The applications are to be developed in English and Spanish. The objectives are to:

* illustrate the significance of media literacy in the mass media age; clarify the importance of integrating media literacy into the traditional curriculum.
* explain the different methodologies used for reading and producing images.
* understand the differences between a constructed representation of reality and reality itself.
* analyze audiovisual resources available for creating an illusion of reality.
* provide basic information on media useful to multimedia application developers.
* provide an environment for content anchored language learning such as the projects described in the section below.

Foreign Language Projects

Languages will be taught in the future less from a book-centered approach and more from an immersion in authentic speech. The ability of multimedia computer technology to provide a simulated environment in which the sounds and images presented to the student reflect the native speech and culture of a foreign country makes it a powerful tool for language instruction, perhaps second only to actually being in the other country.

As a result of work started during Project Athena, MIT is an international leader in this effort. The Athena Language Learning Project at MIT created award-winning multimedia computer applications to teach French and Spanish. Dr. Janet Murray (Senior Research Scientist), Gilberte Furstenberg (Senior Lecturer in French), Douglas Morgenstern (Senior Lecturer in Spanish), and Professor Suzanne Flynn (who specializes in Linguistics and English as a Second Language) all from the Foreign Languages and Literature Section, and Evelyn Schlusselberg and Ben Davis (currently CECI researchers) developed these applications. Much of this research continues in the Laboratory for Advanced Technology in the Humanities, a research group under the direction of Dr. Murray that is affiliated with CECI.

Since CECI started, additional projects in Spanish (involving CECI staff and Evelyn Lillienfeld, a lecturer in foreign languages, and Japanese (with Dr. Janet Murray and Prof. Shigeru Miyagawa) have been completed. This work continues as a collaborative effort between the Foreign Languages and Literature Section and CECI.

CECI and LATH will be entering into a collaboration with the University of Paris to develop cross cultural and multilingual computer applications that can be used in the teaching of French and English. This may include applications that allow exploration of film materials in both languages and cultures.

The Robert R. Taylor Network

Working with the Black Alumni/Ae Association of MIT, CECI has been developing a new initiative to create a computer-based archive that documents the contributions of African-American scientists, engineers and architects. This project has produced a first prototype computer application. In the longer term, we are seeking support of a project called the Robert R. Taylor network that would have three major features:

* the creation of a network-accessible archive that could be used by scholars and teachers.
* the implementation of a series of projects that would be undertaken by secondary school students who would add contributions to the archive.
* the development of specific educational modules for distribution to public schools (K-12) that can be used by teachers in curricula either in the sciences or history. These modules would introduce students to the scientific contributions of people of color in the United States.

Visualization of Multi-Attribute Queries and Databases

As the amount of computer-based information grows and the tools to retrieve that data become more sophisticated, it is becoming increasingly difficult for people to formulate appropriate queries for electronic information and to understand the
results of these queries. CECI is developing a set of graphical tools that use color, shape of polygons, geometric layout, shading and other visual queues to manage such information.

This project is supported by the Union Bank of Switzerland. Mr. Anselm Spoerri, a graduate student based at CECI, has developed the key ideas in this project. Faculty and research staff from CECI, the Laboratory for Information Decision Systems and the Media Laboratory are involved in advisory roles.

**The Shakespeare Interactive Archive Project**

The Shakespeare Interactive Archive Project, directed by Prof. Peter Donaldson and Dr. Janet Murray, is creating a prototype software environment for studying text and film of Shakespearean plays as an aid to learning and to scholarly research. This project addresses key questions of how to index and annotate electronic and performance texts so that they are readily accessible to multiple, concurrent users. These efforts coincide with a shift in emphasis in Shakespeare studies toward the serious study of performance at the micro, or highly detailed, level. This project is being done at the CECI-affiliated Laboratory for Advanced Technology in the Humanities.

The Shakespeare Archive is also expected to contribute in the long-range to work in Film and Media Studies at MIT, in particular the effort to access film materials in relation to text and commentary and to create a new kind of classroom in which video and text sources are integrated and made readily available for analysis.

**Museums, Archives and Libraries**

Museums, archives and libraries share a common need to provide information to broad constituency. CECI has been working with several such organizations to explore the potential of computer and communication technologies to aid in this mission. In several cases, CECI staff have created prototypes of computer applications that allow users to browse the rich information resources of such organizations. Specific projects include:

- a project with the MIT Museum to create an multimedia collection describing the life and work of Doc Edgerton. This project is the first in a proposed series on famous MIT researchers.
- a prototype of an application (and a proposal for continuing work) on new techniques for computer-assisted reading for the new Bibliotheque de France.
- the development of a computer application that presents the history of architecture at MIT. This project is being done with the MIT Museum and the School of Architecture and Urban Planning.
- a prototype with the Smithsonian Museums showing a portion of their Native American collection.
- a project being undertaken with the Rotch Library to deliver portions of their collection of still images over the campus network.
- a prototype for human interface research for the Musee D'Orsay in Paris.

**Learning Reading Through Popular Video-Based Materials**

CECI is working with the Harvard Graduate School of Education in developing multimedia computer applications that use a combination of popular video materials and synchronized, text-based captions to motivate students who have had problems learning to read. Funding for this work, being done with Dr. Carol Chomsky at Harvard, is currently being sought.

**Journal of Science Education and Technology**

CECI is the home for a new journal in the use of information technology in science education. The publication is entitled the *Journal of Science Education and Technology*. It covers all levels of education, including K-12. Dr. Karen Cohen, a Senior Research Associate, is the editor of the journal, and Prof. Steven R. Lerman, Director of CECI, is on the editorial board. Plenum Press is the publisher.

MIT faculty and research staff are encouraged to use the journal as the scholarly publication of choice for educational computing. This connection will provide peer review for young faculty who are interested in this area but are concerned about how such work will be recognized in the tenure and promotion process.

**Conference on the Uses of Multimedia in Training**

In December, 1992, CECI organized and hosted a symposium on the uses of multimedia computer applications in life-long education, particularly in corporate settings. This conference brought together approximately 60 people for an entire day to discuss the major lessons learned during Project Athena and the new initiatives in educational computing underway at MIT. Speakers at the conference came from industry and academic, including CECI, IBM Corporation, Dartmouth University, and consultants or corporate training.
Summer Workshop on Multimedia

This summer CECI will offer its first workshop on the creation of multimedia applications for K-12 teachers. This workshop will provide a small group of educators a “hands-on” experience with computer-based education. Topics will include the evaluation of existing multimedia materials, the integration of computer-based materials into existing curricula, the technologies involved in multimedia and the major software tools used to create educational applications. Teachers in this one week course will work with CECI staff to create simple applications and to modify existing materials created by CECI.

Multimedia Course on Probability, Statistics and their Application to Manufacturing

CECI is starting work on a project funded through the ARPA Technology Reinvestment Program to develop undergraduate level course modules to teach probability, statistics and their application to quality control in manufacturing. This effort is part of a larger, five university program called the Realization Project under which the universities will develop and share a range of educational materials that they create. The computer-based multimedia modules will be created by CECI researchers working with Profs. Drake, Larson, Lerman and Welsch, all of whom have taught various courses in this area.

This project is scheduled to run for three years starting in the summer of 1994. The first modules should be ready for testing by the end of the first year.

The Geology Tutor

CECI has supported an ongoing project on the development of a computer-based tutoring system for introductory geology. This project is directed by Prof. Herbert Einstein of the Department of Civil and Environmental Engineering. The Geology Tutor has both expository and testing modules on various aspects of geology, particularly those that affect the design of foundations for major construction projects. It is used extensively in an undergraduate course on geotechnology taught by Prof. Einstein.

RELATIONSHIPS WITH OTHER MIT ORGANIZATIONS

To be successful, CECI must establish working relationships with many other organizations both at MIT and elsewhere. These relationships are mutually beneficial, with both CECI and the other organizations gaining from the cooperation. One pattern of cooperation already emerging is where MIT academic departments or outside organizations provide their substantive knowledge of some field and CECI provides the computer application design/implementation expertise to build an educational system.

This section describes some of the most significant of the relationships already formed or envisioned as important to achievement of CECI’s goals in the next five years.

Academic Computing Council

CECI is closely tied to the MIT Academic Computing Council. The Director of CECI chairs this council, and the group acts as an informal steering committee for the Center. Major initiatives for CECI are discussed within the Council, and members of the Council are often active in these efforts. This close working relationship will continue, with Council members providing the core of the affiliated faculty of the Center.

Black Alumni/ae Association of MIT

CECI has developed an ongoing relationship with the Black Alumni/ae Association to work together on creating multimedia archives on the contributions of African-American scientists, architects and engineers. The first project, a prototype on the work of Robert R. Taylor, the first university-educated African American architect from MIT, has been completed. A larger project that includes educational programs for secondary school students and an ongoing data collection effort is now being developed.

Center for Advanced Engineering Studies

We are currently working closely with the Center for Advanced Engineering Studies. In addition to sharing some computational and video production facilities, we have been collaborating on the Mechanical Engineering Design Project. One of the CAES visiting fellows from industry is working with CECI on our library image server project.
The MIT Libraries

There is substantial opportunity for collaboration between CECI and the MIT Libraries. As discussed above, the libraries are one of the major participants in the Distributed Library Initiative (DLI). CECI may play a major role in some of the research initiatives under the larger umbrella of DLI, particularly in the area of image delivery. As part of Project Athena, several CECI staff worked on the pilot electronic image delivery system that provided network access to a collection of 3,000 slides in the Rotch Visual Collection. We are planning to update that system to provide broader access and digital images. (The earlier system used analog transmission of images via the MIT CATV system.)

The MIT Museum

In addition to working together on the Edgerton project, CECI and the MIT Museum are collaborating on developing a computer-based information system on the Museum’s collection. Through this system we plan to make text, images and eventually video segments that describe elements of the collection accessible over the MIT campus network and the Internet. We are also developing several proposals together on other topics, including the computer-based presentation of the drawings and other materials in the Museum’s architecture collection.

Information Systems

CECI retains a close working relationship with the part of MIT Information Systems that now operates the Athena Computing Environment. This relationship includes shared facilities, seminars, and joint participation in several initiatives. Some of CECI’s current computing capability runs the Athena software system and is maintained under contract by Information Systems. While CECI operates computers for its research needs that are not part of the Athena system, some portion of our computer system will be kept Athena-compatible.

Current research in CECI is developing enhancements to the Athena computing system in areas such as multimedia and scientific visualization. To the extent that CECI demonstrates the importance of new technologies in university education, these capabilities will over time be incorporated in some form in the Athena system. Clearly, such technology transfer will be very case-specific, depending on the costs of the technology and the funding available for the Athena system. Because of their physical proximity in Building E40, CECI and Information Systems share some facilities.

CECI STAFF AND SPACE

CECI currently has ten MIT employees (including the Director of the Center), ten full-time visiting research scientists and approximately 18 graduate and undergraduate research assistants. Five of the MIT staff currently in CECI were part of Project Athena.

The center currently occupies approximately 2400 square feet of usable space on the third floor of Building E40 (The Muckley Building). This space include nine offices totaling about 1300 square feet, cubicle space for student assistants and administrative support, and six carrels intended for use by UROPS. The center also has a small video editing studio in the basement of E40. This facility is used for making master videotapes and working videotapes used in the development of multimedia computer applications. All of the work areas are equipped with network connection to the campus network and cable TV access. This infrastructure is essential for the research done at the Center, particularly our work with multimedia computing.

Many of the initiatives in CECI will be done in the space of the home departments of the participating faculty. In the long run, CECI should become a hybrid between a “virtual center” and a more conventional research laboratory. Some of the research of the Center will be done by full-time staff housed centrally in CECI space, while other projects will be done by faculty, students and staff belonging to other groups on campus. This approach will allow CECI’s activities to expand without requiring a commensurate growth in the Center’s space.

GOALS FOR NEXT FIVE YEARS

CECI has a number of objectives goals for the next five years. In particular, CECI has adopted the following goals:

- CECI should continue to be part of several major, state-of-the-art initiatives in educational computing. These initiatives should draw on the Institute’s traditional strengths in computer and communications technology and our recognized leadership as an educational institution.
- CECI must become the focus of a community of faculty, staff and students who share a common interest in educational computing. This is essential because most of our academic departments have only one or two faculty
with interests in this area. Without a more Institute-wide community, these individuals lack both the peer support and financial resources for sustained, effective research.

- CECI should provide a testbed for new ideas that, if successful, can influence the campus computing environment built under Project Athena. In effect, part of CECI's role is to explore the possible strategic directions the campus computing environment should take and to identify those directions that, at least in small scale experiments, seem the most promising.
- CECI should increase the group of undergraduate and graduate students who, while working on degrees in various other academic departments, want to focus their research on educational computing.
- CECI should assist faculty in finding the external funding needed for educational computing initiatives. This assistance will take the form of direct fund-raising, help in proposal preparation, provision of seed grants for promising new ideas and the organization of consortia.
- When appropriate, CECI should provide technical assistance to educational computing projects. For example, CECI staff should include individuals with specialized skills that can be used as part of a number of different projects, no one of which could support someone with that expertise full-time.
- CECI's initiatives should have a direct effect on the MIT curriculum, ideally affecting some of the fundamental, core undergraduate subjects at MIT.

STEVEN R. LERMAN
The CMRAE year-long subject, Materials in Ancient Societies: Plants, was taught by faculty from three consortium institutions: Professor Julie Hansen (Boston University), Professor Lawrence Kaplan (University of Massachusetts, Boston), and Professor Carole Mandryk (Harvard University). Nine students from four institutions enrolled.

The first formal review of the center, carried out by the Office of the Provost, was the major event of the academic year. A seven-member committee, including four scholars from other institutions and three MIT faculty members, met in March 1993 to review the center’s research and education programs, its contributions to MIT, to the discipline of archaeology, and to the CMRAE consortium at large.

The committee’s majority report stated:

[T]he MIT program was internationally regarded as a leading program in the field and the MIT faculty to be outstanding. ... It was the sense of the committee that archaeological science has a special affinity to the MIT atmosphere because of its strong connection between scientific methodology and technology to humanistic studies. This point was made repeatedly in our meetings.

Thus far CMRAE has greatly enhanced the archaeological science capabilities in the Boston area and has very significantly enhanced educational opportunities for MIT undergraduates both in the classroom and in research. The professional archaeologists on our committee felt that the program could provide an excellent base for a unique graduate program in this area.

Six members of the committee were generally convinced that with relatively little difficulty MIT could establish itself as having the strongest academic program in archaeological science in the world. ... An expanded CMRAE could provide professional interaction between many faculty from disparate departments at MIT and hence might fulfill an important function toward integrating the Institute socially as well as intellectually. These committee members feel very positive about the future of archaeological science at MIT.

In spite of the review committee’s enthusiastic endorsement, the Provost decided to close CMRAE as of 30 June 1994. Following submission of its report by the Ad Hoc Faculty Committee on the Closing of CMRAE, convened by President Charles Vest and Chairman of the Faculty Robert Jaffe, whose charge was to look into the process by which CMRAE had been reviewed, Professor Heather Lechtman and Provost Mark Wrighton will meet in an effort to resolve the situation.

As news of the center’s projected closing reached the scholarly community, President Vest has received a steady stream of letters from individuals throughout the world, arguing for the uniqueness of the center, for its unparalleled value as an educational endeavor, and commenting upon its international renown. One scholar’s remarks echo those of all the others: "I want to repeat that there is no other research unit in the world that is conducting archaeological science as is the Center at MIT."

HEATHER LECHTMAN
The Council on Primary and Secondary Education (CPSE) includes representatives from all of MIT's schools and is developing and overseeing programs which bring the strengths of MIT to the American K-12 educational system.

The Council believes that education weaves throughout the social, economic, and political fabric of America—every citizen has a stake in the success of the country's educational system. Because our society is increasingly permeated by science, mathematics, and technology, every citizen should have a foundation in those subjects so that he or she has the interest and ability to acquire the levels of competence needed to work in the modern workplace and to make informed decisions as a member of a democracy.

In the past year, the Council has continued to develop and strengthen its programs.

Professional Growth of Educators
The Institute for Learning and Teaching (TILT) engages and supports community-based teams of teachers, school administrators, and interested volunteers (parents, school board members, university representatives, or industrialists) from across the country in an annual professional development program that rekindles their interest in learning, develops their skills in teaching, and prepares them for implementation of systemic K-12 education reform.

In 1993, TILT conducted a program entitled "How a City Works." It began with a summer institute that ran from July 12-30. Fifty-seven individuals made up ten teams representing Madison Park High in Boston; the Edison Middle Learning Center in Dallas, TX; Stockard Middle School in Dallas, TX; the Falmouth School Department, ME; Keefe Technical High School, Framingham, MA; Jonas Clarke Middle School/Minuteman Regional Vocational Technical High School, Lexington, MA; Lowell Public Schools, MA; Greater Lowell Regional Vocational High/Middlesex Community College, MA; Sarah J. Hale High School, NY; and the Yarmouth School Department, ME.

Teams came to MIT's campus for three weeks to engage in research, science, and engineering as a means of experiencing the design processes that structure physical and social systems. Last year's focus offered participants an opportunity to learn a systems engineering approach through the research of two large-scale urban systems, telecommunications and large-scale construction projects. By participating in small research groups, participants learn how to build effective teams, how to reach consensus, how to brainstorm future plans, and how a school system might change to accommodate a systems approach to learning and teaching.

Teams left MIT with the mandate to share their experiences with colleagues in their home community and to promote school improvement. During the summer institute, each team worked on its design for a program based on the philosophy and techniques of How a City Works. Throughout the remainder of the year, members of the MIT design team and UROP students who facilitated the summer institute visited and advised teams in their evolving plans.

This portion of the CPSE program was supported in 1993 by The Pew Charitable Trusts, National Science Foundation's Engineering Coalition of Schools for Excellence in Education and Leadership, Polaroid Corporation, Texas Instruments, Central Artery/Tunnel Project, ComEnergy, New England Telephone, and NYNEX. In 1994, "How a City Works" will run from July 11-29 and will focus on health care and power generation. Support for the UROP students was provided by the MIT Class of 1992.

Teacher Fellows
As potential change agents, individual teachers drawn from separate schools are not as effective as a core of teachers from one school. The teacher fellows program has therefore been revised to focus on four master mathematics teachers at Cambridge Rindge and Latin High School. With the enthusiastic support of their school administration, they will be released from 20% of their teaching responsibilities in fall 1994; they will continue to teach their regular classes in the remaining time. Their schedules will be arranged so that the free time of each teacher coincides. These teachers will discover, clarify, and document the practice and the strategies that are most effective in encouraging students to learn, understand, and practice mathematical reasoning. Their classrooms are now the sites for student observations by MIT students in the MIT/Wellesley Teacher Preparation Program. The students meet weekly with Fellows to discuss their observations.

This program is supported with a two-year grant from the Department of Energy that begins in the fall of 1994.

Teacher Certification in Massachusetts
To foster the continuing growth of a cadre of new teachers who meet MIT's standards of excellence in science, mathematics, and technology, MIT, in conjunction with Wellesley College, offers undergraduates preparation for Massachusetts teacher certification. This program started in the fall 1993 semester and attracted six students. This spring, two more undergraduates joined the original six. The program requires undergraduates to take three courses at MIT and one at Wellesley; then they are ready for practice teaching.
The Noyce Prize, a $10,000 prize provided by the Noyce Foundation, was awarded this year for the first time to Sarah H. Buta, a senior in materials science. The Noyce Prize is awarded to an outstanding undergraduate student who completes a degree in science, mathematics, or engineering and who elects to teach in the public school system.

As part of the state certification requirement, students in the Teacher Preparation Program must take a course in classroom observation and analysis, which includes 75 hours in classrooms. MIT students are now observing in the classrooms of the teachers who will be Teacher Fellows in the fall 1994. The final project for the course this semester emerged from this MIT undergraduate-Teacher Fellow interaction: students created the documentation, tutorials, and sample problems for a software language package lacking those features that was used in one of the Fellow's classes.

Maintaining the Lines of Communication: Project Access
The community of teachers involved in CPSE programs is continuously growing, augmented each year by the community-based teams that participate in our professional development program and by Teacher Fellows. Project Access is evolving from this community of teachers. In summer 1993, each team was loaned a laptop computer with communications software. This will be continued, with additional training in the use of the computers included in the summer institute.

Changing Public Attitudes
An essential component of the American educational system is the public's attitude towards educational achievement. Recognizing this, the Council is exploring ways to increase the public's appreciation for educational achievement, particularly in the fields of mathematics and science. The Council is creating partnerships with the media, the Boston Museum of Science, the Massachusetts Department of Education, and the business community, including public relations and advertising professionals, to reach a wide audience.

New England Science Teachers
A significant program that shares CPSE's goal of technological literacy for all students, although it is outside of the direct purview of the Council, is the Science and Engineering Program for Middle and High School Teachers. Key to a good education is an enthusiastic, knowledgeable teacher. Since 1989, we have produced a program that endeavors to give educators a unique perspective of how the basic sciences, mathematics, and engineering intertwine to meet the technological challenges and needs of commerce and society. The alumni of this program, now totaling approximately 300, become members of the New England Science Teachers (NEST). This year, NEST members came to MIT's campus on June 30th for a two-day meeting to assess the program and determine future directions for the organization. These meetings are essential to maintain contact and to foster collegiality amongst the NEST membership.

Outreach Activities on Campus
Last year, the Council surveyed the campus regarding educational outreach activities, querying over 16,000 people. The results were published in MIT's Educational Outreach Programs 93-94. Over 100 entries are listed, spanning a wide variety of outreach activities by individuals, groups, and offices at MIT. A new booklet is now in production, and we expect it to be available early in the fall of 1994.

New Joint Venture with ScienceMedia, Inc.
ScienceMedia, Inc., is a new toy company created by MIT alumnus Joan Roth that promotes science literacy through toys and TV, the goal being to attract children usually turned off by science. Science kits will contain all necessary equipment for an experiment, full instructions, and science trading cards. The first product line will focus on Better Sports Through Science. Red Auerbach of the Boston Celtics has agreed to serve as an advisor to a Sports Advisory Council, composed of sports figures, that would assist in the development and marketing of the kits. Through an agreement reached in June, MIT's name and logo will appear on the kit box. The Council will share in the royalties from the sales of the kits.

Future Plans
The Council is now exploring a potential collaboration with the Association for the Advancement of American Science's Project 2061 and is proposing a "Center for Educational Innovation" based at MIT. This center would consist of a consortium of local school systems; community colleges, technical schools, and universities; state departments of education; industrial and public agencies; MIT alumni; and teacher groups. It would focus on curricula and professional development for student-centered learning programs with familiar technologies as the theme.

There is growing interest in Washington and within the business community in the President's School-to-Work Opportunities Act, passed into law during the second session of the current Congress. School-to-Work is consonant with the vision represented in the Council's agenda and will, perhaps, present an opportunity for MIT to work collectively with both the Department of Education and the Department of Labor in moving the nation toward meaningful science, mathematics, and technological education for all Americans.

R.M. LATANISION
Facilities Use Committee

Reporting to the Provost, the Facilities Use Committee formulates and implements policy for the use of Institute facilities by recognized MIT groups, guests from off-campus, and by non-MIT organizations hosted by Faculty and recognized campus groups.

Chaired by Stephen Immerman, Director of Special Services, Office of the Senior Vice President, this year's committee membership included Susan Allen, Assistant Dean, Residence and Campus Activities; Roderick Arthur, Assistant Athletic Director; Mary Callahan, Assistant Registrar, Schedules; Nancy Cavanaugh, Administrative Officer, Music and Theater Arts; Gayle Fitzgerald, Associate Director for Special Events and the Information Center; Michael Foley, Manager, Campus Activities Complex; Anne Glavin, Chief, Campus Police; Bonny Kellerman, Associate Registrar, Academic Services; Sandra Lett, Administrative Assistant, Athletics; Mary Morrissey, Director of the Information Center and Special Events; Paul Parravano, Assistant for Community Relations; Mary Tobin, Supervisor, Operations Center; Tina Trager, Scheduler, Campus Activities Complex; and Phil Walsh, Director, Campus Activities Complex.

A few changes in committee membership occurred this year. Tina Trager was introduced as a permanent member and Secretary of the Committee in September 1993. Sandra Lett replaced Roderick Arthur upon his retirement. He attended his final meeting on February 28, 1994. The Committee approved an increase in Chapel fees for wedding ceremonies, a revision in the Annual Scheduling Process, and the implementation of an updated Event Registration Form.

During the 1993-94 year, in addition to a number of smaller meetings, the Institute hosted meetings of the World Economic Forum, Black Women in the Academy, Episcopal Convocation, Massachusetts Biotechnology Council, Boston Psychoanalytic Society and Institute, and the Acoustical Society of America. In addition, the Institute hosted the Quality Management Conference, the Diagnostic Pathology Conference, the Annual Whitehead Institute Symposium, the Massachusetts State Science Fair, Boston Latin Graduation, Massachusetts Special Olympics, and the English Language Services Pre-MBA Summer Institute co-sponsored by the Sloan School of Management and Conference Services.

Stephen D. Immerman
For the past five years the Office of the Provost has developed and implemented a community wide educational program designed to eliminate (to as great a degree as possible) harassing behavior at MIT. Although primary responsibility for this effort has rested with the Associate Provost for Institute Life, it could not have been undertaken without the cooperation and active engagement of a great many individuals and groups at the Institute, including the Special Assistants to the President, the Secretary of the Corporation (past and present), the Office of Undergraduate Education and Student Affairs, the Office of the Graduate School, the Office of Personnel, the Campus Police, the Chair of the Faculty, the Academic Deans and their department heads and administrative officers, the Office of the Vice-President, the Academic Council, the Medical Department, the Manager of Personnel and the ombudspersons at Lincoln Laboratory and the undergraduate and graduate student governments and their representatives, to name many but by no means all of those who have been involved in this intensive effort.

There were two major goals of this program. The first was to publish *Dealing with Harassment at MIT*, a detailed description of the multi-access, multi-option grievance system that MIT has developed over the past quarter of a century. Produced after extensive consultation with over fifty staff, faculty and students at the Institute, major credit for its acceptance must go to these consultants, whose comments and criticisms helped to make the document workable in a complex community. (Special credit is also due Professor Mary Rowe, Secretary Kathryn Willmore and her assistant, Clara Diebold, as well as to the members of the Weekly Discussion Group (see below)). Over twenty thousand copies of this volume were distributed during the Academic Year 1993-94 and preliminary reports suggest that the guide has had an impact well beyond the MIT community as many of MIT'S sister institutions have come to know of its existence.

The second major goal is to educate supervisors, including faculty, with respect to the contents of this document while simultaneously developing their skills as complaint handlers functioning within MIT's multi-access, multi-option system. This program, which has now completed its first year, is centered around small group discussions with staff and faculty that focus on videos of simulated complainant/respondent/complaint handler sessions. Made by members of the MIT community from composite complaints over the years, the video format has proved to be extremely successful. From September 1993 to the present 531 staff and 201 faculty, a total of 732 individuals, have attended these seminars. Plans are in place to continue with this program until the entire supervisory community has attended.

There are two other independent activities designed to improve quality of life at the Institute. The first is a series of faculty dinners. Faculty members are randomly selected from the entire roster or MIT faculty. Approximately 30-40 faculty attend each dinner. During the past year the Associate Provost has hosted nine dinners. A total of 250 faculty have attended. Held once a month during the school year these dinners have developed into pleasant social occasions where faculty often meet colleagues whom they might otherwise never encounter at the Institute. Additionally, however, these dinners have become a new source of communication between faculty and administration since a portion of the dinner hour is given over to discussion of whatever issues are on the minds of the faculty. The major points of these discussions are regularly reported to the senior administration of the Institute.

A committee, sometimes known as the Weekly Discussion Group meets regularly to discuss important local issues that impinge on community life. This committee is distinguished by two properties. First, its members as a group have first hand experience with complaint handling at the Institute since, in one respect or another, dealing with complaints is an integral part of the responsibilities of its members. As a consequence the members of the group have acquired a degree of expertise which can and frequently does shed light on the nature of some of the problems the individuals in the group might encounter in the course of a year. Second, the proceedings of the committee are completely informal. It has never been appointed, has neither secretary nor staff, keeps no records of its informal discussions. As such it functions much like a support group for people who deal with very difficult problems to seek as well as to offer advice from others whose responsibilities include dealing with such problems. The members of this committee do not constitute a node on any reasonable organization chart of the Institute. Rather they cut across responsibilities and functions and are held together by a common interest in making MIT a decent place to work and learn. Despite (or perhaps because of) its informal nature, this group has served as a model elsewhere in the Institute, having spawned a similar group in the Human Services Network.

Finally, with this report the position of Associate Provost for Institute Life comes to an end and a new position, Special Assistant to the Provost, will replace it. The activities just described will continue as before.
INTRODUCTION

The Office of Educational Opportunity Programs was created in January of 1992 to organizationally locate both the MIT/Wellesley Upward Bound and MIT Educational Talent Search Programs. MIT has operated the Upward Bound Program since 1966 and began operation of the Educational Talent Search Program in September of 1991.

Upward Bound and Educational Talent Search are two of six US Department of Education: Special Programs For Students From Disadvantaged Backgrounds (TRIO Programs) created under the Higher Education Act of 1965.

The goal of these Programs is to provide college admission and preparatory information, academic support, advising, career information, and college and career exploration opportunities to the economically and/or educationally disadvantaged youth of Cambridge.

To a large extent, the development of both Programs was influenced by the research done by psychologist Kurt Lewin and his associates. Lewin's hypothesis was that ego growth and academic performance were closely related. Moreover, he concluded that a developing ego needs to experience success in a warm and personal, structured environment for greatest development, in both a personal and social sense. Lastly, it was determined that this personal and social growth could be achieved through intervention outside of the institutions of family and school. Educational Talent Search and Upward Bound, through their year-round academic support and advising, represent just such an intervention.

It has been long established that the effects of failure can be reversed through gradual structured achievement. Moreover, the result of the increasing success is a corresponding increase in the individual's level of aspiration. The Educational Talent Search Program, now in its third year, is reporting increasing success. Further, the Upward Bound Program continues its lengthy record of success (90+ percent college enrollment of graduates and 70 percent retention of participants annually) achieved during its 27 year existence through the application of Kurt Lewin's theory and careful attention to the impact of Program expectations.

Finally, since much of what students think they can achieve has been directly related to what others think they can accomplish, the participants' perceptions of their abilities are, to a significant degree, determined by staff expectations. Thus, and largely due to this quasi-parenting relationship, the Programs are able to exert such an influence upon the participants that their academic persistence grows and results in increased post-secondary enrollments.

MIT EDUCATIONAL TALENT SEARCH

The MIT Educational Talent Search Program is a year-round, co-educational, program, located in Building 20, designed to assist participants, in grades 6-12, who live and/or attend school in Cambridge, to continue in a course of education leading to graduation from secondary school and enrollment in post-secondary educational programs. The Program is funded to serve 600 participants from disadvantaged backgrounds.

The following is an overview of the Program's year-round operation:

ACADEMIC YEAR PROGRAM

The academic year program is designed to inform, assist and support participants during the school year through a number of after school, evening and weekend activities:

Tutorials & Study Skills

The Educational Talent Search office is open for supervised study, on a drop-in basis, four days a week: Monday - Thursday from 3:00 p.m. to 8:00 p.m. Staff are available to provide assistance with homework or provide tutorial assistance in content areas. Students are assigned to group or individual study skills workshops on an as needed basis.

Instruction & Workshops

The Program offers self-paced instruction in Mathematics and Language Arts to supplement the instruction received by participants. Additionally, workshops are offered to provide more specific support or to address special interests (e.g., SAT preparation, Word Processing, Computer Games, etc.).
Advising
In an effort to assist participants as they attempt to cope with problems of an academic, social, family or personal nature, the Program offers support and referrals in the areas of school guidance, academic and vocational preparation, and personal adjustment.

Information Dissemination and Exploratory Activities
In an effort to provide both participants and their families with information relative to college; choice, preparation, and the admission and financial aid processes, the Program held four parent information nights, took participants to four local College Fairs and sponsored 7 college visits. The Program also visited the Tufts Medical Center and Woods Hole Observatory as part of its career exploration effort.

Cultural and Recreational Activities
The Program provided 5 field trips for the purpose of increasing the intellectual, social, and cultural development of the participants. Some of the sites visited were; Museum of Science, Boston Garden and Butternut Basin Ski Resort. In addition, the Program visited several points of interest, i.e., libraries, museums and laboratories, on the MIT campus.

SUMMER PROGRAM
The summer program provides both academic instruction to 72 (6th-8th) grade participants and a continued college information and exploration program to participants in grades 9-12.

The summer academy for (6th-8th) grade students provided classes in Mathematics, Language Arts, and Social Studies. The classes, held Monday-Thursday, are designed to provide both developmental assistance and enrichment and are taught by experienced teachers from the greater Boston area. Field trips are taken every Friday to local points of interest.

Since many of the participants in grades 9-12 hold summer jobs, the Program provided continuing support through dissemination of information about area college fairs, hosted a career speaker series and sponsored two college visits.

MIT/WELLESLEY UPWARD BOUND
The MIT/Wellesley Upward Bound Program is a year-round, co-educational, multi-racial, college preparatory program for high school youth who reside or attend school in Cambridge. Currently in its twenty-seventh year, the Program serves 70 academically promising young men and women from disadvantaged backgrounds. The goal of Upward Bound is twofold: (1) to motivate client high school youths such that they persist on to post-secondary education; and, at the same time, (2) to provide them with the fundamental skills necessary for success at the collegiate level.

The following is an overview of the Program's operational phases:

SUMMER PROGRAM
The six week summer program, conducted in residence at Wellesley College, is designed to provide the participants with a rigorous academic experience. Classes are taught by experienced high school teachers, and graduate and undergraduate students from MIT, Wellesley College and other local colleges and universities. Upward Bound participants must enroll in three classes, each of which meets for an average of five and one-half hours per week. Also, participants may request or be assigned to tutorials whenever the need arises. Each participant is required to enroll in a Mathematics course, an English course and an elective course (Social Studies or Science). Science electives include; biology, chemistry, physics and computers while Social Studies address United States, African-American and World Histories. The Mathematics courses range from arithmetic to calculus and Language Arts courses cover basic English and grammar through research paper writing and literature. Lastly, due to an agreement with the Cambridge Public Schools, students may receive summer school credit for failed courses taken for review.

ACADEMIC YEAR PROGRAM
The academic year program located at MIT, plays an equally important role in the educational development of participants. Building upon the motivation and enthusiasm developed during the summer, the academic year program is designed to assist and support the participant while in school. To accomplish this task, the following programs, staffed primarily by MIT and Wellesley College students when appropriate, (We continually strive to maintain MIT and Wellesley College students' participation through our continued involvement as a pre-practicum site for the Wellesley College Teacher Certification Program and through various outreach efforts.) have been developed:
**Tutoring and Study Skills**
The Upward Bound office is open for study, on a drop-in basis, four days a week: Monday and Thursday from 3:00 to 6:00 pm and Tuesday and Wednesday 3:00 to 8:00 pm. Tutors are available to assist participants with homework problems in addition to meeting individuals and/or small groups for specific content area tutorials.

**Classes and Workshops**
The Program offers classes in Mathematics and Language Arts to supplement the instruction received at the target school. Also, academic workshops are offered to address more specialized participant needs (e.g., SAT preparation, Computers, Foreign Language, etc.).

**Advising**
In an effort to help participants cope with the myriad of problems; academic, social, family, etc., the Program offers support in the areas of guidance, college, career and personal adjustment.

**Cultural and Recreational Activities**
The Program provides numerous field trips which have as their purpose, the intellectual, social and cultural development of the participants. Some of the trips have visited; the Museum of Science, the New England Aquarium and the Computer Museum.

**COLLEGE REPORT: CLASS OF 1994**
Ninety percent of the Program's graduating seniors have enrolled in the following institutions: Clark/Atlanta University, Boston University, Brandeis University, Fitchburg State College, Lasell College, Northeastern University, Providence College, Salem State College, Spelman College, Temple University, University of Delaware, University of Massachusetts at Amherst, University of Massachusetts at Boston, University of Massachusetts at Lowell, and Wentworth Institute of Technology.

RONALD S. CRICHLOW

EVETTE M. LAYNE
INTRODUCTION
It has been a year of extraordinary accomplishment for the arts at MIT. New facilities have opened in music, theater, and visual arts; enrollments in curricular offerings continue to rise; the faculty in the arts has achieved ever wider recognition, as have our programs; and visiting artists of the highest caliber have enriched campus life both inside and outside the classroom. Over all of this achievement, however, hangs a darkening budgetary cloud. As MIT struggles to close a serious budgetary gap, Institute funding to arts programs has been cut at a time when outside funding has become harder to realize. Unless new sources of income can be tapped, it will become more and more difficult to maintain the upward trajectory in arts programming or even to sustain what has been achieved.

ARTS PROGRAMS
The mission of the arts at MIT, both curricular and co-curricular, is threefold: (1) to achieve the highest standards of excellence within the context of MIT; (2) to integrate the arts with other programs at the Institute; and (3) to take a leadership role in the arts locally, nationally, and internationally.

Achieving excellence
The curricular programs at MIT in the arts as elsewhere strive to achieve three goals: (1) professional training at the highest levels; (2) an opportunity for deep involvement at a non-professional level; and (3) introductory training to provide an avenue for lifelong enrichment and enjoyment. The arts at MIT have always provided (2) and (3); as the programs and faculties strengthen, MIT can increasingly provide (1) as well. In this year’s graduating class, at least three students have chosen to pursue graduate studies in the arts: two in music and one in writing. These students were sought after by the best schools in the country and had their choice of programs. In the past two years, students have chosen careers in music, theater, writing, and the visual arts.

The MIT students who choose professional arts careers do not differ significantly from those who pursue the arts in depth but go on to fields of science and engineering. Most students in these two categories double major, and most are professionally qualified in at least two fields. In the past year, MIT students not pursuing professional arts careers had their artwork displayed at First Expressions Gallery in Boston, one performed in a solo recital at Symphony Hall, one had his artwork profiled in the Boston Herald, and one has his work chosen to represent Technology Day 1994. Further, the MIT Symphony was repeatedly singled out for review in the Boston papers, which is highly unusual for a student group, and one concert was described by the Boston Globe’s chief music critic Richard Dyer as “a model of what every concert ought to be.”

The curricular programs are enhanced by a growing Artists-in-Residence (AIR) program. In the past year, through the efforts of Professor Evan Ziporyn, MIT has acquired a full Balinese Gamelan, and students have had the opportunity to work closely with Balinese artists in their study of this orchestra of instruments. Students in theater have been able to work directly with Brazilian playwright, Augusto Boal, and with playwright David Henry Hwang, who in the annual Abramowitz lecture spoke of the problems and opportunities facing Asian-Americans in the arts and who coached students in the presentation of his play FOB.

The curricular programs also benefit from the support of the Council for the Arts at MIT (CAMIT). In the past year, for example, CAMIT has made possible the purchase of North Indian musical instruments to support the teaching of George Ruckert, Lecturer in Music, and the acquisition of new teaching materials for the music library and new equipment for the Student Art Association. Because of MIT’s budgetary problems, it is only through CAMIT that such programmatic support has been possible.

CAMIT support has been absolutely essential in the expansion of curricular arts facilities. In the past year, the suite of new music practice rooms in Building 4 was dedicated to the Council for the Arts. These rooms were made available exclusively through the generosity of three CAMIT members. Also the opening of Building E-33 as a theater design facility housing costume, set, and lighting design classes, workshops, and storage was facilitated by significant support from CAMIT.

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Our faculty artists represent the core of excellence in the arts at MIT. In the past year, their work has been widely recognized both inside and outside MIT. Professor Wellington “Duke” Reiter was recognized by CAMIT with the Kepes Award and presented the inaugural Gyorgy Kepes Fellowship Prize lecture; in the Boston Globe, Professor Reiter was recognized in a cover story on “Artyecture.” Professor Alan Lightman continued to receive national attention for his first novel, Einstein’s Dreams; at MIT he led a well-attended workshop at Technology Day 1994 of MIT writers reading from their works. Professor Alan Brody’s plays continued to be produced nationally with a
Anxious Salon, interested in the arts community at MIT, worked with Michael Behnke, Director of Admissions, to increase the role of The Creative Arts Council (CAC), a faculty and administrative group that meets monthly to discuss issues of critical recognition. Such integration is facilitated.

As the excellence of the arts programs is more widely recognized, the arts have become increasingly integrated into the fabric of the Institute. As the arts have been requested for loan or reproduction across a wide spectrum of international organizations, including the Smithsonian and WGBH-TV.

The List Visual Arts Center has continued its history of awards and recognition with receipt of formal accreditation with distinction by the American Association of Museums. The List Center was also invited to present one of the inaugural year exhibitions for the new American Center in Paris next year. As in past years, the collections of the MIT Museum were requested for loan or reproduction across a wide spectrum of international organizations, including the Smithsonian and WGBH-TV.

The MIT Museum was changed permanently with the acquisition of the entire collection of the New York Museum of Holography at auction. With the addition of this collection to its holdings, the Museum now boasts the largest collection of historical holography in the world, which is only appropriate as it contains works by both President Charles M. Vest and Professor Stephen Benton, former Head of the Media, Arts and Sciences Program. As in past years, the collections of the MIT Museum were requested for loan or reproduction across a wide spectrum of international organizations, including the Smithsonian and WGBH-TV.

The List Visual Arts Center has continued its history of awards and recognition with receipt of formal accreditation with distinction by the American Association of Museums. The List Center was also invited to present one of the inaugural year exhibitions for the new American Center in Paris next year. As in past years, one of its exhibits, The Anxious Salon, was again praised by the Boston Globe as one of the year's ten finest in this area.

Integration of the Arts into the MIT Community
From undergraduate admissions to graduate research to the growing body of alumni and alumnae, the arts have become increasingly integrated into the fabric of the Institute. As the excellence of the arts programs is more widely recognized, such integration is facilitated.

The Creative Arts Council (CAC), a faculty and administrative group that meets monthly to discuss issues of critical interest to the arts community at MIT, worked with Michael Behnke, Director of Admissions, to increase the role of the arts in admissions procedures. Because of faculty concern some years ago about the quality of students admitted when the Admissions Office sought students with a more "well-rounded" background, CAC has rather focused its efforts in those areas of admissions that are not directly involved with the selection process. Studies done by the Admissions Office have shown that prospective students who choose not to apply to MIT or not to attend the Institute after admission frequently make that decision of a perception that the arts and humanities are not broadly represented or well respected here. It is essential, therefore, that we try to reach those students so as to increase the pool of qualified applicants and to increase the yield of admitted students. To succeed in this effort would benefit the entire undergraduate program at the Institute.

We began working with Admissions last year by having student and faculty representation in the arts at Campus Preview Weekend for the first time. Next year we plan to reach all prospective students identified as "highly qualified" with a letter describing the opportunities in the arts and humanities at MIT including a request form for the new Student Guide to the Arts. The Admissions Office will try to identify applicants with arts interests, and it will forward submitted slides and portfolios to the Department of Architecture for faculty review as it has for years submitted tapes and compositions to the Music Section. Members of the arts community will continue to participate in Campus Preview Weekend, and we will try to have representation at alumni receptions for admitted students during spring break. Faculty will participate in contacting individual admitted students who have been identified with arts interests.

CAC was also actively involved in the extended discussions over the year about the role of the arts in HASS-D. Unfortunately this issue was not resolved, as a recommendation from the HASS-D Review Committee to group the arts with offerings in the humanities and thus encompass within a requirement was not welcomed by critics on both sides of the question who either wanted to see the arts more fully represented or left as an optional, non-required category. Further discussions were then held under the direction of Professor Arthur Smith, Dean of Undergraduate Education and Student Affairs; these were productive but without resolution. Encompassing the arts category within a HASS-D requirement remains a goal of the arts programs.

The acquisition of the largest single holography collection by the MIT Museum has led to a new partnership with the Spatial Imaging Group at the Media Lab. With the creation of a holography collection at the Museum, a new and significant educational component will be established for adults, MIT students, and area K-12 students. Over the year the Museum strengthened its relationship with the Department of Ocean Engineering through the Hart Nautical Collection, the Department of Architecture through the Architectural Drawings Collection, and the Department of Electrical Engineering through the Edgerton Project. Its final exhibition of the year
Light*Space*Time: CAVS/MIT - 25 Years highlighted the artistic and educational achievements of the Center for Advanced Visual Studies.

The AIR program has always been conceived as having a significant curricular component. This year the program has worked extensively with the Music and Theater Arts Section. Next year, in addition to collaborations with curricular areas in the arts, the AIR program has planned artistic residencies in Mechanical Engineering and in the Edgerton Center.

The Boston Club of MIT Alumni/ae highlighted the arts at MIT by choosing the arts as their focus for the distinguished Windows on MIT lecture series. Speakers included Joe Haldeman, science fiction author and Lecturer in Writing and Humanistic Studies; Professor Peter Donaldson on interactive Shakespeare studies; Professor Woodie Flowers on engineering design; Dean William Mitchell on digital imaging; members of the music composition faculty led by Professor Peter Child in discussions and performances of very recent work; and Professor Steven Benton on holography.

"The Wonder of it all: Technology Day 1994" focused for the first time on the arts. At Tech Night at the Pops, a work by Professor Harbison was performed; David Deveau, Lecturer in Music, was the featured soloist in a piano concerto by Ravel; and Professor Paul Gray, Chairman of the MIT Corporation, led the Boston Symphony Orchestra in a rousing performance of Sousa's Stars and Stripes Forever. At Kresge Auditorium the next morning an overflow crowd of alumni/ae heard Professor Philip Morrison speak on the relation of art and science; I. M. Pei '40 speak on the completion of his work at the Louvre; Richard Polich '65 speak on his work as head of the largest American arts foundry; and Lloyd Schwartz, Pulitzer Prize winner in music criticism, speak with Professor Harbison and Professor Tod Machover on music composition. In the afternoon workshops were held in media arts, writing, architecture and design, theater, and music. As the weekend continued, visiting alums were invited to take tours of the galleries at the List Visual Arts Center and the MIT Museum, of the outdoor sculpture collection, and the new biology building, and to attend the official opening of the CAVS exhibit at the MIT Museum. The weekend culminated with a breathtaking performance of A.R. Gurney's Love Letters, played by Professor Gurney himself and Kitty Carlisle Hart, long-time member of the Council for the Arts. Tech "Day" was covered by journalists from National Public Radio and Scientific American.

Leadership in the arts
In addition to achievements on campus, the MIT arts community has continued to expand its leadership internationally, nationally, and locally. The List Center has long been recognized internationally; its selection as one of the inaugural presenters at the American Center in Paris, along with the Whitney Museum of American Art and the Museum of Contemporary Art in Los Angeles will only add to that reputation. MIT's hosting of Salman Rushdie and his appointment as Honorary Visiting Professor of the Humanities also received international coverage; MIT is the first educational institution to have recognized Rushdie since he was forced to go into hiding as the result of a death threat.

This past year also saw the publication of the proceedings from the conference, "The Public Patron: drafting a mandate for a federal arts agency," presented at MIT in June 1993. This volume has received and will continue to receive wide national distribution.

Locally, the arts at MIT have continued to take a leadership role in education and community affairs. The MIT Museum has expanded its educational program, So You Think Math and Science Are Boring, with funding from the Trustee of the Lowell Institute. The AIR program built new collaborations with Emerson College and Brandeis University and established new partnerships with the Cambridge Public Schools, World Music, and the Cambridge Multicultural Art Center; it expanded its collaboration with IBA-Arte y Cultura. In a Boston Herald article, Maureen Costello, Director of Special Programs in the Arts, was singled out as the motivating force behind the MIT Office of the Arts "acting as a kind of informal hub" of new and exciting collaborative efforts between local educators and arts presenters.

FUND-RAISING
Fund-raising for the arts is facilitated by Glenn Billingsley, Major Gifts Officer for the Arts. A significant part of our annual success is due to the generosity of the Council for the Arts, and a separate report from this group follows. Other initiatives are made to individuals not associated with the Council, to foundations, corporations, and public funding. Overall giving, including gifts-in-kind but not pledges, was up somewhat from $1,097,512 last year to $1,268,520, but this masks disturbing trends that will need to be addressed.

Council for the Arts
Gifts to the Council were down from $189,660 in FY93 to $165,398, approximately the FY90 level. Gifts by Council members to other arts projects increased slightly from $299,900 to $306,000. The reduced level of unrestricted
annual giving meant that for the first time since 1987 the Council needed to draw on its reserves to meet annual commitments. It is possible that interest in the Council’s special projects, which have been very successful in the past few years, including the Berenice Abbott Photography Laboratory, the music practice rooms, and the theater design facility, in addition to special projects initiated by Council members themselves, including funding to support student theater productions, an annual colloquium on contemporary art, the MIT Museum, the List Visual Arts Center and other areas, has drained the availability of support for more general purposes. However, the annual fund supports the Museum of Fine Arts membership allowing all MIT students free admission, the grants program in the arts for students, faculty, and staff, and allocations to the AIR program, the MIT Museum, the List Visual Arts Center, and Arts Communications and has become essential to the maintenance of current operations. Thus the future direction of Council support will be a critical issue of discussion with the Council’s Executive Committee next year.

Other giving
The MIT Museum benefited greatly in the past year due to increased giving from foundations and corporations. Among the most significant of foundation gifts, the Shearwater Foundation provided $20,000 to help support a curator of holography, the Edgerton Trust provided $70,528 to support the cataloguing and multimedia application of Edgerton materials, and the Getty Foundation provided $30,000 to support the cataloguing of the Architectural Drawings Collections. Significant corporate support included $80,000 from Eastman Kodak for preparing, cataloguing, and exhibiting the holography collection, approximately $50,000 in loaned equipment from SONY Electronics to the CAVS exhibition, and about $13,000 in loaned equipment from Apple Corporation for the CAVS exhibition. Also the List Visual Art Center’s exhibition Masculine Masquerade will receive significant support from the Andy Warhol Foundation and the National Endowment for the Arts totaling $45,000. One very important gift-in-kind was the donation by Norman Gordon ’43 of his extensive audio tapes fully organized and catalogued within cabinets to complement his previous gift of an extensive library of chamber music scores and parts valued at $107,253. All arrived at MIT last spring and are in the process of being unpacked with great appreciation and enthusiasm by the music faculty.

AFFIRMATIVE ACTION
The offices under the supervision of the Associate Provost for the Arts continue to have very strong representation of women on their staffs; the position of Retail Coordinator at the MIT Museum was vacated this year and filled by a minority male who is an MIT alumnus. The programs of the Office of the Arts continue to highlight artists of all cultures and ethnic backgrounds. In the past year the AIR program celebrated Asian and Asian-American arts and artists; the past two years celebrated African-American and Hispanic arts and artists. The Associate Provost took on the additional responsibility last year of chairing the presidentially-appointed Campus Committee on Race Relations.

Ellen T. Harris
ARTS COMMUNICATION

In the fifth year of the Office of the Arts, Arts Communication continued to successfully collect and publish accurate, up-to-date information on MIT's extra-curricular and co-curricular arts programs and events; disseminate this information to the MIT community, prospective students, the Cambridge/Boston community, the general public, and the press; actively promote and cultivate awareness of the arts at MIT both within and outside the Institute, for public relations, publicity, and fundraising purposes; oversee publicity and promotion efforts for programs sponsored by the Office of the Arts; and advise and assist individual arts programs and members of the arts community in their publicity and public relations efforts.

Significant projects and media coverage of the arts at MIT included the following:

Internal (MIT)

Arts Communication produced the second edition of "The Arts at MIT: A Student's Guide," with information on extracurricular arts activities available to students. Copies were distributed throughout campus and to incoming students at the Fall '93 Activities Midway.

For the fifth year, Arts Communication produced the weekly Arts Page in Tech Talk. Nineteen feature Arts Pages and eight Month-at-a-Glance Arts Pages were produced by Lynn Heinemann (writer) and Susan Cohen (designer). In addition to Tech Talk's weekly distribution, poster copies of each Arts Page were distributed widely on and off campus, and Arts Page stories were made available on-line. A corps of student photographers was hired to document campus arts events for the Arts Page and other on-campus publications, and the office's growing collection of photographs was used widely in various MIT publications and by the media.

There was a significant increase in the number of feature stories on MIT arts news and events in Tech Talk's general spaces: 30 arts-related articles were published in Tech Talk's "run-of-paper," more than twice as many as in the previous year. Authors included the director of arts communication, members of the News Office staff, and members of the MIT arts community.

Other MIT publications featured MIT arts-related articles as well. Arts coverage in The Tech increased dramatically in amount and improved in quality under Arts Editor Ann Ames. Coverage included thoughtful reviews of MIT performances and exhibitions, feature stories/previews on students involved in the arts, and calendar listings of arts/entertainment events. MIT arts-related features also appeared in MIT Spectrum, the SHSS News, and Technique.

Arts Communication continued to oversee ArtsNet, which grew to a total of over 90 campus arts representatives. Arts Communication also continued to oversee maintenance of the "Arts at MIT" bulletin board in Lobby 7 and the weekly "Arts Hotline" (253-ARTS).

IAP activities increased to include over 100 arts-related programs, workshops, and performances, and were designated in the IAP Guide with the code letter "A." Separate listings of arts events occurring during IAP were prepared by Arts Communication and distributed throughout the Institute.

Technology Day 1994, which focused on the arts at MIT, increased awareness of MIT's arts programs and activities for thousands of MIT alumni/ae. An article in the May/June 1994 issue of Technology Review previewing Technology Day declared that "arts involvement permeates every corner of the Institute" and that the arts are "fully integrated into the curriculum and into the central teaching and research of the faculty." The event was covered by the Director of Arts Communication for Tech Talk. Journalists from National Public Radio and Scientific American attended the event.

The Windows at MIT series, which this year focused on the arts at MIT, also increased awareness of MIT's arts programs and artists for MIT alumni and friends.

Work began on an arts brochure project, which includes the writing, design, and production of the following: a new arts brochure for general fundraising and public relations uses, brochures for the Council for the Arts at MIT and Special Programs, and a student's guide to the arts at MIT.

Proceedings from the conference, "The Public Patron: drafting a mandate for a federal arts agency," presented in June 1993 by the Office of the Arts, were edited and published. Copies were distributed at a major conference presented by the National Endowment for the Arts in April, 1994. Distribution is continuing both within and outside of MIT.
Local and National
Copies of the Month-at-a-Glance arts page were mailed to over 500 off-campus individuals at their request.

Arts Media Calendars were produced and mailed monthly to 265 members of the electronic and print media. Press releases and posters were produced for major events and announcements, and mailed locally and nationally to targeted writers and media sources. Relationships continued to be cultivated with members of the media, resulting in successful article placements and increased external awareness of MIT's arts programs.

Local media attention given to MIT artists-in-residence included enthusiastic preview and review coverage of Nusrat Fateh Ali Khan, Augusto Boal, Ephet Majurul, Les Ballets Bougarabou du Senegal, Los Pleneros de la 23 Abajo, Phil Woods and the Phil Woods Quintet, and Gamelan Sekar Jaya by the Boston Globe and other print and electronic media. The appearance of playwright David Henry Hwang as the 1994 William L. Abramowitz Lecturer received advance coverage by the Boston Globe, the Boston Phoenix, the Christian Science Monitor, WHDH-TV Channel 7 "Asian Focus," and others. While at MIT, Hwang was interviewed for a feature story on National Public Radio.

The surprise appearance of author Salman Rushdie at MIT in November, 1993 received nation-wide attention from the national electronic and print media.

Alex Beam of the Boston Globe devoted a recent column to "Boston's new bastion of arts: MIT." Interviews with Associate Provost for the Arts Ellen T. Harris and others led Beam to conclude that "with little fanfare, MIT has transformed itself into a world-class mecca for performers of all stripes."

Art New England prepared a series of two articles, written by Charles Guiliano, on the Center for Advanced Visual Studies in conjunction with the Center's 25th anniversary and retrospective exhibition at the MIT Museum.

For the second year in a row, MIT's List Visual Arts Center made the Boston Globe's "Top Ten in Visual Arts" list—in 1993 for The Anxious Salon: Narrative Content in Recent Figurative Painting.

A Boston Herald article attributing the rise in Boston's world music events to collaborative efforts between local educators, presenters and arts administrators, praised MIT's Office of the Arts for "acting as a kind of informal hub of it all," and singled out Director of Special Programs Maureen Costello as the force behind these successful collaborations.

Boston Globe music critic Richard Dyer heralded a concert by the MIT Symphony Orchestra as "a model of what a student concert ought to be... Student musicians were engaged with great music and serving a community that was eager to participate in the experience.... it was clear that what this had become was a model of what every concert ought to be."

The first-ever collaborative effort by the MIT Concert Choir and the MIT Symphony Orchestra—a performance of Verdi's Requiem, directed by John Oliver—won high reviews from the Boston Globe. "This was a responsible and contained performance as well as an exciting and moving one," wrote Richard Buell.

A Cambridge Chronicle story on cultural activities available to the general public at the city's universities featured MIT's galleries, concerts, and film and writers series.

List Foundation Fellow Malay Kundu was profiled in a Boston Herald article, "Students with a mission—Visual Arts."

A concert by the Tokyo String Quartet, presented as part of the Acoustical Society of America's annual meeting, was written up in The New York Times, the Boston Globe, and other publications.

MIT Artists Off-Campus - Selected Media Attention
Assistant Professor of Architecture Wellington ("Duke") Reiter was featured in a Boston Globe Magazine article on "Artyecture" by architecture critic Robert Campbell, who called him the Artyitects' "most audible spokesman"; Professor John Harbison received enthusiastic praise for his conducting appearances and compositions, including his new Cello Concerto, premiered by Yo-Yo Ma and the Boston Symphony and rehearsed with MIT student pianists, which garnered impressive previews and reviews from the national press; Professor Alan Lightman continued to receive national attention for his novel Einstein's Dreams, including a feature story by Boston Globe writer David McLean; Dean William Mitchell's work with digital imaging was featured in Art New England, Scientific American, and others; Assistant Professor Evan Ziporyn's work as a composer and performer was praised by the Boston Globe, New York Times, and others; in a review of lecturer Beth Soll's "Temenos," Boston Globe dance critic Christine Temin remarked that Soll's solos were always "the most successful pieces on the program."

MARY L. HALLER
SPECIAL PROGRAMS

In its fourth year, the Artist In Residence Program continued to thrive as a curricular-based, multicultural program and began a celebration of Asian and Asian-American arts and artists. In collaboration with Emerson College, distinguished Balinese artists Nyoman Catra and Desak Made Suarti Laksmi began a two-year residency at MIT and worked with MIT's Gamelan Galak Tika to develop the students' music and dance sensibilities. Under the guidance of these artists, Galak Tika presented several public performances at nearby universities. In April they joined California's renowned Gamelan Sekar Jaya in a performance for a standing-room-only crowd at MIT. Sekar Jaya, while in residence at MIT during their first east coast tour, also presented public lecture-demonstrations on Balinese music and dance. Additional highlights of the "arts of Asia" celebration included appearances by the famed Persian Qawwali singer, Nusrat Fateh Ali Khan and the Japanese "tiko" drummers, Ondekoza. The annual Abramowitz program featured playwright David Henry Hwang, who gave a public lecture and worked intensively with students in the Theater Arts Program. Students were particularly enthusiastic about Mr. Hwang's accessibility as a young Asian-American artist.

The Residency Program continues to build inter-university collaborations for programmatic and budgetary reasons. Augusto Boal, Brazilian playwright, author and legislator, trained 50 students from MIT, Emerson College and Brandeis University in image and forum theater techniques. Public lectures were offered at MIT and Emerson.

Other residencies included a two-week advanced theater program with artists Teresa Ralli from Peru and Rosa Luisa Marquez from Puerto Rico. Jazz drummer Max Roach, mbira player Ephat Mujuru, Afro-Cuban music and dance ensemble Yoruba Andabo, choreographer Rosalind Newman, and the Urban Bush Women dance troupe added much to the cultural life of the community.

Three partnerships with Cambridge-based institutions were established. The Cambridge Public Schools, World Music and the Cambridge Multicultural Art Center (CMAC) all collaborated on programs sponsored by the Office of the Arts. Several residency artists offered programs specifically for elementary grade students from the Boston and Cambridge Public Schools. "Boston Rhythm," a collaborative project with World Music and CMAC featured Boston-area artists in an effort to support the local artistic community. We look forward to strengthening and expanding these three partnerships next year.

Through an on-going collaboration with IBA-Arte y Cultura, members of the Boston cultural and educational community continued to share programs. A new Boston partner, First Expressions Gallery, provided an opportunity for members of the Student Art Association and student musicians to showcase their work both at Symphony Hall and at a newly-opened gallery for university student artists.

The List Foundation Fellowship supported three full fellows and three students with mentor awards. One Fellow was accepted into Boston University's graduate program in creative writing with a full scholarship; another plans to pursue an acting career.

The Residency Program continued its work with the School of Humanities. A major focus on New Music in the 20th and 21st Century is planned. In addition, over the next three years, the program will focus its attention on the development of residencies in science and engineering departments. Three programs are in place for the coming year; additional programs await funding.

Maureen Costello
Through the prudent and generous leadership of John W. Kunstadter '49, Chairman, and Martin N. Rosen '62, Vice Chairman, the Council for the Arts at MIT completed the most active year in its history during 1993-94 (FY94). Enhanced work by its standing and prize committees, new initiatives to foster student engagement with the arts, and support for a variety of Institute priorities characterized the Council's partnership with the MIT arts community this year.

COUNCIL STANDING COMMITTEES

Annual Meeting (Catherine N. Stratton, Chair)

The Twenty-first Annual Meeting of the Council for the Arts at MIT was held on October 28-29. Ninety Council members and guests attended the meeting.

For the first time, this special occasion was organized to highlight one of the six curricular arts disciplines at MIT (architecture, media arts, music, theater, visual arts, writing). With the recent appointment of a new dean and department chairman, Architecture was chosen as the curricular focus of the 1993 Annual Meeting. Featured in the program was a presentation by Dean William J. Mitchell on the changes afforded by interactive communications and imaging technologies to architectural practice and pedagogy. President Charles M. Vest and Provost Mark S. Wrighton also addressed the Council on MIT affairs.

The Eugene McDermott Award and the Gyorgy Kepes Fellowship Prize were presented, respectively, to Thomas Hanrahan and Victoria Meyers, an architectural team from New York City, and to Wellington Reiter, Assistant Professor in the Department of Architecture. (see Special Programs below)

Development (Martin N. Rosen '62, Chair ad hoc)

Fifty-one Council members provided unrestricted contributions averaging $3,082. Twenty-six non-member donors contributed unrestricted gifts averaging $316. For the first time since 1987, expenditures for Council-sponsored programs and activities exceeded revenue.

In addition to unrestricted gifts, fifteen members provided designated contributions totalling $306,000 to other MIT arts programs. These include support for endowment and programs at the List Visual Arts Center and exhibitions at the MIT Museum; the Wasserman Forum on Contemporary Art; and the “Student Playwrights in Performance” series developed by the Theater Arts faculty.

Contributions were also designated to several “Special Projects” undertaken by the Council’s Executive Committee as $50,000 commitments. This year, pledge payments were completed by three Council members for the construction of music practice rooms (see Special Programs below). Also, gifts from nine members were obtained to convert the vacant Rinaldi Tile Building on campus to a permanent home for the lighting and set design classes, and the Costume Shop of the Theater Arts program.

Grants Program (Bradford M. Endicott '49, Chair)

The Grants Committee considered 33 applications for support of arts projects, submitted by MIT students, staff, and faculty, requesting a total of $79,752. From its annual allocation, the committee recommended funding of 28 projects, with grants totalling $77,118. Six Director's Grant proposals were reviewed by the Council Director and awarded a total of $1,250. World Music figured prominently in Council grants this year with six projects awarded funding. A detailed report of the Grants Program activity is available.

At its policy meeting in May, the Committee resolved to reduce by three the number of its application review sessions during the academic year, and to adopt a more proactive posture through open-ended discussions with faculty and staff on large-scale projects.

List Visual Arts Center (LVAC) Advisory Committee (Ruth Bowman, Chair)

The LVAC Advisory Committee, composed of Council members, MIT faculty, and outside museum professionals, held four meetings during the 1993-94 academic year. Subcommittees were established in the areas of Collections, Education and Outreach, Exhibitions, and Fundraising. The Committee allocated $20,000 of Council funds to the LVAC Director as discretionary income. Also, a series of prints by the contemporary artist Judy Pfaff was acquired for the MIT Permanent Collection with unexpended funds from the FY93 LVAC Advisory Committee allocation.

At the request of Associate Provost for the Arts, the Committee was charged with the preparation of an annual advisory report to be submitted at the conclusion of the academic year.
Membership (Bernard G. Palitz ’47, Chair)

At the conclusion of the 1993-94 academic year, Council membership stands at 79, excluding five ex officio members and three Life members. Forty of the 41 members whose terms expired at the end of June were invited to renew their appointment and one individual was recommended for Life membership. To balance term distribution, twenty members were offered two-year renewals.

Seven individuals accepted appointment to the Council upon the invitation of President Vest: John H. Cantlin ’42, Lincoln, MA; Mary McDermott Cook, Dallas, TX; Dorothy Endicott, Dedham, MA; Caroline Goodall, Los Angeles, CA; Felice Kincannon, Cambridge, MA; and Bonita and Robert M. Levin ’63, Chicago, IL.

At the Annual Meeting, two past Council Chairmen and founding class members were appointed to Life membership: Luis A. Ferré ’24 and Paul Tishman ’24.

With sadness this report must note the passing of two esteemed members: Lawrence B. Anderson ’30, Dean of MIT’s School of Architecture and Planning from 1965-1971, who was appointed to the Council in 1973; and Gregory Smith ’30, a member of the Council’s 1972 founding class and long-time chair of the Development Committee. Mr. Smith was appointed to Life membership in 1991.

MIT Museum Advisory Board (Harvey I. Steinberg ’54, Chair)

The MIT Museum Advisory Board, composed of Council members, MIT faculty, and MIT alumni, held four meetings during the 1993-94 academic year. The board allocated $20,000 of Council funds to the Director of the MIT Museum as discretionary income.

At the request of the Associate Provost for the Arts, the board was charged with the preparation of an annual advisory report to be submitted at the conclusion of the academic year. The independent “Report and Recommendations of the MIT Museum Advisory Board” was submitted on June 29, outlining past and current operations of the Museum with recommendations and planning for the future. It is understood by the board that upon review by the Associate Provost for the Arts this document may be presented to Provost Mark Wrighton towards his appointment of an Institute committee to review the MIT Museum.

SPECIAL PROGRAMS

Dedication of the Council for the Arts at MIT Music Practice Rooms

In a ceremony on March 15, the new music practice rooms in Building 4 were dedicated to the Council for the Arts at MIT. This conversion of classrooms into much-needed, soundproof practice rooms was made possible by the funding catalyst of three Council members each of whom contributed $50,000. Offering brief remarks at the occasion were Paul E. Gray ’54, Chairman of the MIT Corporation, Professor Harriet Ritvo, Associate Dean of the School of the Humanities and Social Science, Professor of Music John Harbison, and Professor Ellen T. Harris, Associate Provost for the Arts. Speaking on behalf of the Council was Vice Chairman Martin N. Rosen ’62, who was one of the three generous Council donors for the project. The other donors, Leonard Bezark, Jr. ’49 and one anonymous member, were unable to attend the celebration.

Gala Weekend in Dallas

For the first time in its history, the Council sponsored a multi-day assembly of members and friends off the MIT campus with a splendid weekend in Dallas and Fort Worth, TX from April 22-24. Forty members and guests enjoyed a memorable trip orchestrated by a Host Planning Committee co-chaired by Cecil H. Green ’23 and honorary alumna Margaret McDermott, with the invaluable assistance of members Bill C. Booziotis ’60 and Mary McDermott Cook.

Highlights of the weekend included private tours of the Dallas Museum of Art led by Deputy Director Clay Johnson III ’70; a preview of the Impressionist Masterpieces of the Barnes Collection at the Kimbell Art Museum; and visits to the spectacular homes and art collections of several Dallas residents, including member Raymond Nasher. The group also attended a performance by the Dallas Symphony Orchestra in the Eugene McDermott Concert Hall of the Meyerson Symphony Center, and dined at the Dallas Arboretum and Botanical Gardens. With great generosity and flair, Mrs. McDermott opened the weekend with a festive gathering at her Dallas home and brought it to a fine conclusion with luncheon at the McDermott Ranch.

Museum Membership Program and Performing Arts Excursions

Since 1980, the Council has underwritten MIT’s enrollment in the University Membership Program offered by the Boston Museum of Fine Arts. This program provides free admission and discount benefits to all MIT undergraduate and graduate students, as well as ten membership cards for the daily use of MIT faculty and staff.

This year the Council initiated a series of free student excursions to performing arts events in the Boston area to complement its long-time support of the student membership program at the MFA. The intent of this new program is to offer MIT students opportunities
to enjoy productions ranging from the classical to the avant-garde. Groups of fifty to one hundred students attended five events ranging from "The Madness of King George III" performed by the Royal National Theater of Great Britain to a concert by the Sufi mystic musician Nusrat Fateh Ali Khan, to Handel's "Messiah" with Professor John Harbison conducting Boston's Handel & Haydn Society. This series was a great success, often with as many students on a waiting list as the number of tickets available, and will be expanded next year.

**Endowed Prizes and Awards**

The *Gyorgy Kepes Fellowship Prize* was presented by Angus N. MacDonald ’46, (Kepes Prize Committee chair) to Wellington “Duke” Reiter, Assistant Professor in the Department of Architecture, at the Annual Meeting. An accomplished visual artist and architect, Mr. Reiter was commended in the Kepes Prize citation for: "[building bridges to cross the public and private spheres... encouraging] us to demand an aesthetic of inclusion from the built environment." On May 3, Mr. Reiter delivered the inaugural Gyorgy Kepes Fellowship Prize lecture, entitled "The Necessity for Fiction," in Huntington Hall (10-250).

The *Eugene McDermott Award* was presented by Ida Ely Rubin (McDermott Award Committee chair) to Thomas Hanrahan and Victoria Meyers, an architectural team from New York City, at the Annual Meeting. The McDermott Award citation observed that in the work of Hanrahan and Meyers, "Transformation pervades their architectural designs, which challenge not only conventions of material, structure, and enclosure, but also models of society and culture." As Artists-in-Residence at MIT in November, Mr. Hanrahan and Ms. Meyers offered critiques of student architectural projects and delivered a public lecture in Huntington Hall.

At the Institute Awards Convocation in May, the *Laya and Jerome B. Wiesner Student Art Awards* were presented by Professor Ellen T. Harris to Adrian Childs '94 (Mathematics and Music) for distinguished and versatile music performance, and to Franz Elizondo Schmelkes '94 (Mechanical Engineering and Theater) for acting and multicultural community service. Professor Harris also presented the *Louis Sudler Prize in the Arts* to Christopher Adler '94 (Mathematics and Music) for his accomplishments in music performance and scholarship.

**Tea and Symphony**

On April 8, twenty-five Council members and guests attended a performance by the Boston Symphony Orchestra conducted by Seiji Ozawa. Highlighting the afternoon concert was Professor of Music John Harbison's Cello Concerto commissioned by the Chicago Symphony Orchestra and the BSO, with soloist Yo-Yo Ma. Following the concert, Catherine Stratton hosted a lively reception at 100 Memorial Drive in Cambridge.

**1993 Max Wasserman Forum on Contemporary Art**

The third annual Max Wasserman Forum on Contemporary Art, *Giving Birth to Brightness: African Art in the Post-Colonial World*, was held on October 14. The forum examined the social, historical and formal dimensions of contemporary visual culture in sub-Saharan Africa. Participants included Kwame Anthony Appiah, Professor of Afro-American Studies at Harvard University; Michael Brenson, a New York-based art critic and curator; Moyo Okediji, Lecturer in Afro-American Studies at the University of Wisconsin, Madison; Clyde Taylor, Professor of English and Film Studies at Tufts University; and Sylvia Williams, Director of the National Museum of African Art in Washington, DC. Mark Palmgren organized the forum and served as moderator. The forum was preceded by a two-week program of contemporary African films, *Yeelen, Ceddo, Camp de Thiaroye, and Faces of Women*, screened in the Bartos Theater of the Wiesner Building.

MARK PALMGREN
The year got off to a rousing start with notification that the LVAC had been formally accredited with distinction by the American Association of Museums. Additionally, the curators were invited to organize one of the inaugural year exhibitions for the new American Center in Paris and were chosen as one of four finalists in the competition to select and organize the American entry to the 1995 Venice International Biennale of contemporary art.

The LVAC's Advisory Committee met four times. The group's primary task was the compilation of a Report to the Associate Provost for the Arts on the LVAC's past strengths and future needs. The report will be circulated to Academic Council.

For the first time the LVAC was closed to the public on Mondays, to allow for cleaning and photography in the galleries. However, Wednesday evening hours were instituted in an attempt to accommodate after-work audiences.

EXHIBITIONS
The List Center's 1993-94 exhibition program comprised a lively mix of international and national, one-person and thematic group exhibitions. Of the seven exhibitions presented in the three galleries, five were organized by the List Visual Arts Center. We produced catalogues for four of these; the fifth, Robert Cumming's Blackboard Brain, will be documented in the upcoming publication chronicling the LVAC's artist-in-residence program from 1985 to the present.

Angela Grauerholz: Recent Photographs (Reference Gallery, September 11 - December 19, 1993) This first United States museum exhibition included 14 recent, large-scale black and white photographs by a German-born artist presently living and working in Montreal. Portraits, nudes, landscapes, urban sites and interior settings are among her soft-focused, sepia toned subjects which are situated ambiguously in time and place.

Robert Cumming: Blackboard Brain (Bakalar Gallery, September 11 - December 19, 1993) Massachusetts artist Robert Cumming, known internationally for his fascination with eccentric mechanics and technology, was commissioned to create a new work. In residence during August, he transformed the entire Bakalar Gallery into a continuous, volumetric blackboard covered with chalk drawings and verbal notations which invited viewers into the interior of his restless and inventive mind. During October and November, while in Japan, he periodically faxed additions to this ongoing "diary." Blackboard Brain, which ran concurrently with the retrospective exhibition Robert Cumming: Cone of Vision at Boston's Museum of Fine Arts, was reconstituted at the Contemporary Art Museum in Honolulu.

The Anxious Salon: Narrative Content in Recent Figurative Painting (Hayden Gallery, October 16 - December 19, 1993) This heavily-attended exhibition presented heroically-scaled canvases by five contemporary painters from North America and Europe working within an "Old Master," figurative, narrative style. Vincent Desiderio, Attila Richard Lukacs, Odd Nerdrum, Hanneline Rogeberg and Thomas Woodruff update the academic tradition with psychologically complex or disturbing contemporary content. The Anxious Salon was cited by the Boston Globe as one of the year's ten finest exhibitions.

Dan Graham: Public/Private (Hayden and Reference Galleries, January 15 - March 27, 1994) This retrospective exhibition highlighted the 30-year career of this pioneering figure in the development of conceptual art in film, video, photography and performance. His architectural models and glass and mirror structures engaged the viewer in recognizing the physical, psychological, and social interactions occurring within public and private spheres. The exhibition was organized by the Goldie Paley Gallery at Moore College of Art and Design in Philadelphia.

Maria Fernanda Cardoso: Recent Sculpture (Bakalar Gallery, January 15 - March 27, 1994) This young Colombian artist, now residing in San Francisco, has devoted much of her artistic energy to exploring the bond between humans and other animal species. This first United States museum exhibition focused on sculpture the artist created from preserved animals and other organic materials. Cardoso
fashions preserved snakes, frogs and other fauna into minimalist forms or organic shapes; often referring to
the stylized positions characteristic of pre-Columbian decorative motifs.

**Pieter Laurens Mol** (Hayden and Bakalar Galleries, April 16 - June 26, 1994) This Dutch artist creates
conceptually based art which addresses the moral and aesthetic contradictions of the modern age. Through
the use of elusive images combined with symbolic alchemical materials such as sulfur, zinc, rust,
gunpowder and lead, his constructions push the boundaries of communication through a poetic interplay of
thoughts, words and images. **Pieter Laurens Mol** was organized by the Stedelijk van Abbemuseum,
Eindhoven and will travel to Montreal, Houston, and Cincinnati.

**Sandy Walker: Woodblock Prints** (Reference Gallery, April 16 - June 26, 1994) This California artist
exhibited 16 large, dramatic woodblock prints which hover between abstraction and representation.
Though based in nature (the artist often carries his huge plywood blocks into the fields or woods) the prints
are less the mirror of a specific location than an evocation of the rhythms and pulses of the natural world.
Organized by the LVAC, the exhibition will travel to three other museums around the country.

**EDUCATION PROGRAMS**
Each exhibition was supplemented with educational events including panel discussions and artist and
curator-led gallery talks. Highlights included large tours for alumni/ae of the LVAC, outdoor Permanent
Collection and new Biology Building; the artist and curator-led panel discussion for *The Anxious Salon*; the
slide lecture presented by Mark Francis, Curator of the Andy Warhol Museum on the work of Dan Graham;
and James Melchert's discussion of his ceramic mural for MIT Biology faculty and students and Physical
Plant staff. List Center curators led a number of tours for professional and student groups, from MIT and
other schools. In its inaugural year, the weekly "curator's lunch hour" drew a steady stream of visitors
interested in an opportunity to talk one-on-one with members of the curatorial staff. For World AIDS Day
1993, painter Thomas Woodruff gave a slide lecture discussing work by artists whose work addresses the
AIDS crisis.

**GRANTS AND FUNDING**
We received two major grants, from the National Endowment for the Arts and from the Warhol Foundation
totalling $45,000 for the upcoming exhibition *Masculine Masquerade*. Other donations, both individual and
foundation, some ongoing (not counting in-kind contributions) brought our grand total of outside support
received to $247,995.

**COLLECTIONS**
The MIT Permanent Collection acquired 14 works of art through gift and four by purchase. The Student
Loan Art Collections acquired three works by gift and 13 by purchase. In the new Biology Building through
MIT's One Percent for Art policy, James Melchert's ceramic tile wall was installed; Jim Sanborn's privately
funded lobby installation will be completed early in the summer. New York sculptor Jackie Ferrara was
commissioned to provide an artwork for the floor of the main level of the new Tang Center at the Sloan
School.

Extended loans to the collection are as noted in previous reports.

With a deaccession policy approved and in place, the LVAC sold Robert Grosvenor's *Untitled*, Jasper
Johns's *Figure Seven*, Hans Hofmann's *Blue Interior* and Ogden Pleissner's *Out for Ducks* at auction
through Sotheby's, New York.

The Henry Moore, Isaac Witkin, Michael Stein and Jacques Lipchitz outdoor sculptures were cleaned and
repatinated by Steven Tatti. The Jean Lurcat tapestry was cleaned and reattached and the Nicholas
Schoeffer cleaned, repaired and reactivated.

**MISCELLANEOUS STAFF NOTES**
Katy Kline presented a one-hour program on contemporary art for the Massachusetts Corporation for
Educational Telecommunications which was satellite-transmitted to high schools around the country. She
also served as Visiting Critic for the Jerome Foundation, Minneapolis; Juror for the Duke University
Museum regional painting exhibition and Program Evaluator of the Weatherspoon Art Gallery at the University of North Carolina, Greensboro.

Helaine Posner served as a Juror for the Maine Arts Council grants distribution and was active on the Public Art Committee of the Cambridge Arts Council.

Ron Platt juried the Cambridge Arts Council One Percent for Art panel and lectured at the Museum of Fine Arts on the exhibition Jess.

Katy Kline and the List Visual Arts Center Staff
The MIT Museum reached several milestones during FY94 that clearly marked our future direction. One of the most encouraging developments of the past year was a comprehensive review of the Museum’s operations undertaken by the Museum’s Advisory Board at the request of President Vest and Provost Wrighton. Among the Board’s recommendations is a new building to house the Museum’s main facility, which is currently located in an aging converted warehouse some distance from the main campus. Preliminary plans have been developed to renovate a building closer to campus and to raise the funds necessary to realize the Board’s—and the Museum’s—vision of a modern facility showcasing the Institute’s past, present, and future.

One of the most exciting events of the year was the March opening of the premier exhibition of our holography collection. *Holography: Artists and Inventors—The Museum of Holography Moves to MIT* opened with considerable fanfare and has drawn record numbers of visitors. This exhibition represents the first step in achieving our goal of creating a comprehensive holography resource at MIT in partnership with the Spatial Imaging Group at the Media Lab.

Another important development in FY94 was the implementation of several initiatives that emphasized new directions in “high-tech” collections management. During the past year we made significant headway on a collaborative effort with the MIT Center for Educational Computing Initiatives (CECI) to develop an innovative online collections catalog for the Museum’s holdings. The catalog will be completed in FY95, at which time it will be made available to the Institute (and the Internet community) via MITnet. A prototype multimedia application on the history of the MIT Department of Architecture, using drawings and other materials from the Museum’s Architectural Drawings Collection, was completed in FY94. This application, also produced in collaboration with CECI, illustrates how the Museum’s new collections database can be used as the basis for innovative educational programming. Finally, the first large-scale retrospective cataloging and image-capture project for the Hart Nautical Collections, one of the nation’s largest and most significant ship and yacht plan collections, commenced in the spring of 1994 with funding provided by several donors.

**HOLOGRAPHY**

It has been less than a year and a half since the MIT Museum acquired the holdings of the Museum of Holography in New York City, with the help and support of Professor Stephen Benton, director of the Spatial Imaging Group at the Media Lab, President Vest, Jerome Wiesner, Helene Magill, Mary Michieli Rollins, the MacArthur Foundation, and the Media Lab at MIT who provided funds for its purchase. In FY94, principal sponsor Eastman Kodak Company generously donated $80,000 in support of the holography program. Combined with crucial grants and gifts of equipment from the Shearwater Foundation, the Council for the Arts at MIT, William F. Blitzer ’45/Lightolier, and General Scanning, Inc., this funding made possible the initial processing of the collection and the opening exhibition. A generous gift from M.P. and A.R. Arulpragasam ’77 will enable us to establish a significant educational component, including the creation of a holography lab at the Museum. Work has already begun on this facility, where adults, MIT students, and area K-12 school groups will learn the science and artistry behind the creation of holograms. An online educational resource on holography is also on the drawing board, with plans to integrate full-text documents relating to holography, “3-D” images, and instructional materials into our multimedia collections catalog during the coming year.

**COLLECTIONS**

With the advent of the Museum’s new collections management database, retrospective cataloging projects have taken on new urgency. In the past year a scholarly catalog of the Architectural Drawings Collection, consisting of more than 15,000 drawings made by MIT students and significant practicing architects, was researched with funding from the Getty Grant Program. More than 7,000 negatives and 10,000 research slides taken by Professor Harold “Doc” Edgerton were transferred to the MIT Museum in FY94, and are being cataloged as part of the Edgerton Project. The Haffenreffer-Herreshoff Project will enable the curator of the Hart Nautical Collections to efficiently access and reproduce plans from this heavily-used collection of 13,000 yacht plans. The Holography Collection, consisting of more than 1,500 historically, technically, and artistically significant holograms, has also been the subject of an intensive cataloging project during the past year.

Notable accessions during the past year included the addition of over 50 holograms, including several historic holograms donated by holography pioneer Juris Upatnieks, an extensive model train installation from Eva Arnott, several hacking artifacts, a collection of color Schlieren photographs by Professor Kim Vandiver, a portfolio of architectural drawings by William Rotch Ware (MIT student and nephew of William Robert Ware, founder of MIT’s Department of Architecture),
watercolors depicting MIT scenes by Lian Quan Zhen, and artifacts from the Departments of Mathematics, Aeronautics and Astronautics, Architecture, Materials Science, and the Sloan Automotive Labs. Materials from the collections were exhibited at the Haffenreffer Museum, Gardner Museum of Architecture and Design, the Smithsonian, Plainsman Museum, and the American Museum of Papermaking. Images from the collection were used in publications and productions including Yankee Magazine, WGBH-TV, the American Institute of Physics, New Scientist Magazine, the Union of Concerned Scientists, the American Ceramics Society, the Sci Fi Channel, and in a CD-ROM publication by the Computer Curriculum Corporation.

The Edgerton Project
Supported by funding from the Harold E. Edgerton Trust, work began in June 1993 on the Edgerton Project, a collaborative undertaking with CECI to create a state-of-the-art networked multimedia collections database and multimedia educational applications about Doc Edgerton’s career and inventions. More than 7,000 original Edgerton negatives are being digitized and incorporated into the new database, along with digitized video from research films, full-text materials relating to Doc’s career and work, an index of the laboratory notebooks in which Edgerton documented his research for more than 50 years, and images and information about the scientific instruments constructed and used by Edgerton now in the Museum’s collection. This database will serve both as a comprehensive research resource about Edgerton, and as a model for museum collections management that takes advantage of rapidly changing computing and network technologies. It will be used to store multimedia information about all of the Museum’s significant holdings, including the MIT biographical and subject files, which are the collections most frequently used by the MIT community. As retrospective catalog and digitization projects are undertaken during the coming years, the Museum’s collections database will become an increasingly important resource for the study of the history of science and technology, and in particular MIT’s role in these endeavors.

Architectural Drawings Collection
The past year marked the first comprehensive effort to catalog and document this unique collection, which consists of more than 15,000 drawings collected by the Department of Architecture over a span of 100 years. Funding from the Getty Grant Program enabled the curator of the Architectural Collections to research in depth many of the most important architects represented in the collection, and to oversee a cataloging effort which resulted in the complete documentation of hundreds of the earliest drawings. The products of this research will be added to the online collections catalog, and thus will be available to students, researchers, and the scholarly community via MITnet and the Internet.

The curator of the Architectural Drawings Collection also continued research for an upcoming exhibition featuring the Museum’s drawings, set to open in the fall of 1994. From Louis Sullivan to SOM: Boston Grads Go to Chicago will explore the active and influential role MIT-trained architects played in Chicago’s turn-of-the-century building boom. Two rare oversized drawings from the Museum’s collection by Constant Désiré Despradelle, charismatic professor of design for the MIT Department of Architecture from 1893-1912, were conserved this past year for the exhibition. Designed for the 1893 Columbian Exposition site in Chicago, Despradelle’s famous Beacon of Progress was intended to serve as a monument to the spirit of the American people. An elevation plan for the Beacon measuring 12’ x 10’ will serve as the show’s visual centerpiece. Continuing support from Martin E. Zimmerman ’59 is making this exhibition possible.

Hart Nautical Collections
Underway since March 1994, the Haffenreffer-Herreshoff Project will make possible the retrospective cataloging and microfilming of the Hart Nautical Collections’ most heavily used ship plan collection. Funding for the project was provided by the Haffenreffer Family Fund, the Henry B. Plant Memorial Fund, and Joel White ’54. The Museum’s eventual goal is to add the data and images produced in the course of this project to the Museum’s new online multimedia collections database. We will continue to seek funding so that the scope of this work can be expanded to include additional drawings in the Hart Nautical Collections. The continuing support of John A. Lednicky ’44 for general Hart Nautical Collections needs is gratefully acknowledged.

EXHIBITS
With support from the Council for the Arts at MIT, the Office of the Arts, the Alumni/ae Association, and corporate, foundation, and individual donors, the MIT Museum presented:

Galleries at the Main Facility
Thomas Jefferson and the Design of Monticello February 10 through April 24, 1994. This exhibition, organized by the Octagon Museum to commemorate the 250th anniversary of Jefferson's birth, is the first to trace the design and building of Monticello, a prime example of the neoclassical style. Jefferson used his home as a veritable laboratory for his architectural ideas. The exhibition included 25 original Jefferson drawings on loan from the Massachusetts Historical Society. A generous gift from John Carlson '83 helped bring this exceptional exhibition to MIT.

Holography: Artists and Inventors March 5, 1994 - ongoing. The premier exhibition of holograms from the former Museum of Holography in New York explores the holographic universe from its inception in the late 1940s through its artistic and technical evolution. The exhibition highlights works by many of the world's foremost holographers.

Light*Space*Time: CAVS/MIT - 25 Years June 4 through October 2, 1994. Musical stairs, a hologram that has orbited the earth, an electromagnetic pendulum, and a silver cube that fills a gallery with wild, ever-changing light patterns are but a few examples of technological art in this retrospective showcasing the work of more than 25 fellows of MIT's Center for Advanced Visual Studies. The exhibition was supported by the Council for the Arts at MIT, the Dean of the School of Architecture and Planning, and the Eugene McDermott Fund for the Arts. Electronic equipment was provided by Sony Inc. and Apple Computer Inc.

Compton Gallery
Irving Geis: Molecular Art September 23 through October 29, 1993. This exhibition explored the beauty and intricacy of molecular structure. Geis, a scientific illustrator for more than 50 years, joined Scientific American at its inception in 1948 and became one of its most celebrated illustrators. Working with scientists, three-dimensional models, and computer graphics, Geis' complex artworks offer a rare view of how the structure of molecules determines their ability to perform their metabolic functions.

The Face Of Egypt: Photographs by Ellen Shea and Tarek Hamdy November 18 through December 31, 1993. Shea, a graduate student in MIT's Department of Architecture and Hamdy, a 5th-year student at the School of the Museum of Fine Arts Boston, traveled to the village of Kom El Farug, 30 miles southeast of Alexandria, Egypt to photograph the 'izba and the Fellaheen who live, work, and die there, generation after generation. The Fellaheen, the largest and poorest class in Egypt, continue many of the same farming techniques and family traditions as their Pharaonic ancestors.

David Bakalar: Sculpture and Paintings January 21 through March 4, 1994. With an advanced degree in physics from Harvard and a doctorate in physical metallurgy from MIT, Bakalar's work has scientific overtones. Fusing 20th-century techniques and materials, his sculptures and paintings employ a geometric language and multiplicity of planes to address the issues of genetics, cloning, and the linkage of science, technology, and artistic endeavor.

Design To Value March 18 through April 29, 1994. An exhibition that illuminated the industrial design process. How design decisions are made and who makes them, product manufacturability, and the process of bringing a product to market were the areas explored in this exhibition organized by the Design Management Institute. The Apple Power Book and electronic products developed by Northern Telecom and Thomson Consumer Electronics were featured.


Strobe Alley
Optical Alchemy September 14 - ongoing. An exhibition of full-color underwater fluorescent photographs taken by Charles Mazel, a research engineer in the Ocean Engineering Department. Through the optical magic of fluorescence, dull brown and gray living organisms on a Caribbean reef are transformed into vivid gold, green, blue, and red jewels. Matched pairs of images offer a stunning comparison between the subject under reflected-light photography and under illumination with ultra-violet light.

In addition to scheduled exhibitions, the museum staff lent its expertise to shows highlighting the woodcraft projects of a Cambridgeport primary school, a textile competition organized by the MIT Women's League, and the annual children's drawing exhibition at the MIT Medical Department.

EDUCATION PROGRAMS
The Museum's most popular educational program, So You Think Math and Science Are Boring..., continued for its third year with funding from the Trustee of the Lowell Institute. This year, in addition to many returning school groups, students from the MIT Educational Talent Search program and Girl Scouts from the Patriot's Trail Girl Scout Council came to the Museum to participate in educational programs about geometry, holography, and architecture. In addition, students met with MIT graduate students and researchers at a number of labs and centers around the Institute, including the Biomechanical and Human Rehabilitation Lab, Parsons Lab, Magnet Lab, Media Lab, and Strobe Lab.

To complement the Thomas Jefferson exhibition, the Museum designed an exciting array of programs that drew enthusiastic new groups to the Museum. Walking tours, lectures, gallery talks, musical performances, family programs,
even minuet lessons were offered as a source of enlightenment about Thomas Jefferson, design, the architectural process, and about life and technology in the 18th century. The Friends of Monticello at MIT generously supported the educational programming for this exhibition.

FACILITIES
This year, 58 functions were held at the MIT Museum’s conference facilities, serving more than 4,000 people. Some of the more memorable events included the annual Brunel lecture, which this year featured Chairman of the Eurotunnel André Bénard, and gala receptions for the holography, CAVS, and Thomas Jefferson exhibitions. Class reunions, Campus Visits, and numerous receptions and dinners for MIT departments were also held at the Museum.

MUSEUM SHOP
The Museum Shop continued its service to the MIT community by providing high-quality memorabilia, science-related books, and educational games at its two locations and through its mail order catalog. Special promotions during Technology Day drew unprecedented numbers of customers to both retail operations. The Museum Shop in the Student Center continued to provide tickets to the MIT community for Institute events.

IG NOBEL
The third annual Ig Nobel Prize Ceremony took place at Kresge Auditorium on Thursday, October 7, 1993 before a standing-room-only crowd. The event was covered by the major daily newspapers in eight countries and was rebroadcast in its entirety on National Public Radio's Talk of the Nation Science Friday. With a cast of bona fide Nobel laureates, scientists, inventors, students, politicians, Ig Nobel laureates, and Ignitaries all clad in absurd ceremonial regalia, the Ig Nobel Prizes were awarded in inimitable style. The 1993 ceremony saw the debut of the Heisenberg Certainty Lectures—30-second lectures in any medium. Heisenberg lecturers included Nobel laureates Sheldon Glashow, William Lipscomb, and Dudley Herschbach, best-selling author of Einstein's Dreams Alan Lightman, internationally renowned jazz harpist Deborah Henson Conant, and Russell Johnson, professor emeritus of Gilligan's Island. The ceremony was made possible by a grant from the Peter DeFlorez Fund for Humor at MIT.

STAFF CHANGES
Paul DeFanti, Retail Coordinator for the Museum Shop since 1991, left the Museum for a new job in Rhode Island, closer to his home. The Museum welcomes Diego Garcia as the new Retail Coordinator. Diego has worked in the Museum Shop operation since he was a freshman at MIT in 1988.

The MIT Museum Staff
INTRODUCTION

This year has seen substantial reorganization within Undergraduate Education and Student Affairs (UESA). Robert Randolph, who has been the long-time head of the Student Assistance Services Section, has been promoted to Senior Associate Dean. In this role, he will take on a number of tasks affecting the future course of UESA. These include:

- taking the lead in establishing a revised and comprehensive judicial and dispute resolution system for students
- exploring opportunities for raising funds to support the work of UESA
- chairing a Housing Task Force appointed by Vice-President Dickson to create a viable long-range housing plan for the Institute
- seeking to establish better working relations with other departments and offices with whom UESA works
- acting as a resource to the Section Heads on particular problems that involve major interactions with other parts of the Institute or of the external community

Dean Randolph will continue to oversee the Institute’s relation with the MIT Chaplains and in this capacity, he has had a major role in the creation of their new quarters and their new organizational structure. He will also continue to be the lead person in the Institute’s response to sudden death or other major tragedies involving students.

The Student Assistance Services Section has been divided into two new sections:

- Counseling and Support Services
- International Student Office

Deans Jacqueline Simonis and Milena Levak have been promoted to be the Section Heads of these sections, respectively.

Travis Merritt has been promoted to Dean for Undergraduate Academic Affairs and continues to lead that section in this capacity.

With the arrival of Margaret Jablonski as Section Head of Residence and Campus Activities and Richard Brewer as Manager of Administration, a new leadership team is in place and progress in improving the interactions between sections and with the rest of the Institute has occurred. Unfortunately, there will be a change in this leadership in the coming year when Dean Judy Jackson leaves the position of Director of the Office of Minority Education to pursue graduate study at Harvard. A search for her replacement is currently underway.

This has been a good year -- one of substantial, if undramatic, progress in supporting students in their pursuit of their varied goals. Some particular instances of note appear in the descriptions below.

Other promotions
Margaret Enders, Arnold Henderson and Bonnie Walters were promoted to Associate Dean. Susan Allen and Danielle Guichard-Ashbrook were promoted to Assistant Dean. Debbie Shoap was promoted to Staff Associate and Elizabeth Kowal was promoted to Assistant to the Dean.

ARTHUR C. SMITH

SENIOR ASSOCIATE DEAN

The year pulsed with the energy of life and loss that reminds us too often of our mortality. Two students were killed in a tragic plane accident, in the fall; two students died of cancer during the same period. The former shocked us with its suddenness and the latter touched many lives because their illnesses were known and carried by their friends in dorms and classes. In all of these instances, the representatives of the UESA were involved with students in living groups so that the losses might not be devastating to students left to cope with fundamental human concerns.
An accreditation policy for the chaplaincy was adopted by the Academic Council in the spring of 1994. For the first time in the history of the Institute the chaplaincy will be organized into a Board of Chaplains and a Religious Life Council. The former will include full-time chaplains representing mainline denominational groups and the latter will include student religious groups. Both groups will relate formally to the Office of the Dean for Undergraduate Education and Student Affairs.

The MIT chaplains have moved into the building on the corner of Amherst St. and Massachusetts Avenue (W11). The nearly two million dollar renovation of this building was completed in late June. The building includes facilities for Kosher dining and a prayer room for our Muslim students. There are facilities for large and small meetings and space for student religious groups. The building will be dedicated in the fall of 1994.

The building that formerly housed the chaplains is being renovated and, in the fall, will become an annex to McCormick Hall, housing 25 women and a tutor in the fall. The Institute has purchased a building in Back Bay to house a sorority. The addition of these two facilities will satisfy some of the single sex housing needs for women in the fall of 1994.

ROBERT M. RANDOLPH

CENTRAL ADMINISTRATION

The Central Section provides administrative services and facilities support to UESA and houses the Public Service Center (PSC). Among the year’s accomplishments were:

- Office renovations improved the appearance and functionality of the UAA offices in Building 7.
- Extension of the Macintosh network to offices in Building 20 was a major step towards completing the logistical aspects of the merger of Student Affairs and Undergraduate Education initiated two years ago.
- A recently developed database has greatly improved the student activities accounting system.

Affirmative Action Successes and Objectives

UESA’s commitment to Affirmative Action resulted in the addition of one Hispanic female and one African American female to the staff. The UESA staff was 27% minority and 25% male as indicated by the ethnic and gender profile of the 55 full- and part-time UESA staff as of June 1, 1994 printed below.

<table>
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<th>Administrative &amp; Academic Staff</th>
<th>Minorities</th>
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<tr>
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</table>

The 38 administrative staff included 6 African American employees (2 men and 4 women), a Mexican male, an Asian American female, and a Native American female. Of the 17 support staff, 3 were Asian or Asian American females, one was an Hispanic female and one was an African-American female. For Fiscal Year 1995, the UESA plans to increase the number of male support staff and minority representation in all staff levels.

Public Service Center

The MIT Public Service Center (PSC) has finished its fifth complete academic year. The year’s activities included:

- CityDays: A Two-Way Street is a unique partnership with the Cambridge Public Schools. In September, 485 Cambridge public school children came to MIT to participate in a variety of activities ranging from lab tours to sports and crafts. In October, 332 MIT students went into Cambridge and served at local agencies and public schools.
The LINKS program aims to improve the quality of science education in the Cambridge Public Schools. Fourteen student groups were involved in the fall semester and 16 groups were involved in the spring. Each of the volunteers spent from one to four hours/week at one of eight Cambridge elementary schools.

During IAP a six-unit fieldwork-based seminar called Teaching Algebra to Cambridge Kids: A Mutually Liberating Experience was organized to promote active student involvement in algebra in the classrooms involved in the Cambridge Algebra Project. A group of 27 MIT students attended seven two-hour seminar meetings and went into assigned classrooms for seven to eight hours per week throughout the month of January.

Twenty three MIT student volunteers helped the Cambridge Public Schools launch “Experiential Health Days”. All seventh and eighth grade students in Cambridge participated in a day of team-building activities and games held at MIT in January.

Fifteen fellowships of $1,200 each were awarded over IAP and three fellowships of $4,800 were awarded for the summer. The fellows worked with a Science Resource Teacher in an elementary school or with the Coordinator of Educational Technology.

The second annual MIT/Cambridge Science Expo was held at MIT in April. Approximately 100 fifth through eighth graders from eleven Cambridge schools came to exhibit their science projects, participate in hands-on experiments, and tour Institute labs.

The PSC and the CityDays program received generous financial support from the MIT Employees’ Federal Credit Union, the Lord Foundation and the Moses Kimball Fund.

Staff changes
Richard L. Brewer joined the staff as Manager of Administration and Section Head replacing Marilyn Bodnar.

COUNSELING AND SUPPORT SERVICES

This academic year has brought significant change with the reorganization of Student Assistance Services in January. The new name of the counseling office, Counseling and Support Services (CSS), reflects a renewed commitment to the provision of high quality personal counseling services and encompasses the programming for special student groups, work with the Committee on Academic Performance (CAP), the supervision of peer counseling, and Institute outreach/consultation that the office provides.

Counseling Services constitute the foundation of the office, and the three counseling deans experienced a heavy demand for individual counseling. In addition, they served as student advocates in interactions with faculty and Institute offices and arranged special support services such as readers, interpreters, note-takers, tutors, and special consultants.

Support Services take a variety of forms. Selected activities for the year are:

- Facilitation of conflict resolution and discussion between the PBE fraternity and the Black Student Union concerning issues of race
- Meetings with Black students regarding academic success and adjustment
- Coordination of Black History Month and Hispanic Month
- Diversity workshops for Campus Police and for the Inter-Fraternity Council
- Organization and participation in the Martin Luther King lobby program
- Support of Women’s Support Groups (Graduate Women; Women of African Descent; Mujeres Latinas; Asian and Asian/American women)
- Workshops on Date Rape Awareness and Prevention, Harassment in the lab, office and over e-mail
- Women in Film series
• International Women's Workshop

• Service on the Institute Committee on the Americans with Disabilities Act

Counseling and Support Services is dedicated to improving services and maintaining high standards. Crises such as suicide attempts and sexual assault, regular counseling loads, programming, and committee responsibilities combine to severely overtax the staff. The growing complexity of services for disabled students will predictably increase the overload. Another professional staff member is urgently needed to serve the student population at MIT.

JACQUELINE R. SIMONIS  LYNN A. ROBERSON
ARNOLD R. HENDERSON, JR.  BRIMA A. WURIE
AYIDA MTHEMBU

INTERNATIONAL STUDENTS OFFICE

The International Students Office (ISO) came into existence as one of the UESA sections during the past year. The Office has gained a new confidence and stronger sense of purpose from this reorganization.

Approximately 4,000 students have used the services of the ISO during this past year. Fifty percent of these were current students, others were students in various stages of the admissions process and students who had already graduated but continue to require ISO services (for up to 36 months) as required by Immigration regulations.

A variety of reasons prompted this larger than usual number of current students to use this office. U.S. Congress passed a law permitting all Chinese students, who had been in this country before April 11, 1990 to apply for Permanent Residence. The State Department held two Immigrant visa lotteries. The United States Information Agency (USIA) completely revised the regulations for the Exchange Visitors Program establishing new standards of mandatory medical insurance for J-1 students and their dependents. The Internal Revenue Service (IRS) mandated that all international students, whether or not they receive income from a U.S. source, file income tax returns. Finally, an increasing number of students have sought ISO services because they were experiencing financial difficulties.

The ISO has also provided services to an increasing number of MIT students who are permanent residents and students whose families have been admitted to this country as refugees or have been granted political asylum. Currently there is no office on campus that meets the needs of this rapidly growing number of students.

In addition to dealing with immigration issues, the ISO has been active in strengthening relations between the international students and local families in the Boston area. A very successful gathering was held in Lincoln, MA for the new international students and their host families in October and a reception for graduating international students, their families, and their host families, was co-sponsored by the ISO and the Alumni Association.

Finally, the ISO continues to provide leadership and professional support to colleagues from other colleges and educational institutions in the Boston area through the Third Thursday meetings and periodic immigration workshops.

MILENA LEVAK  MARIA M. BRENNAN
DANIELLE GUICHARD-ASHBROOK  BRIMA A. WURIE

OFFICE OF MINORITY EDUCATION

The level of participation and effectiveness of the Office of Minority Education's (OME) academic support programs reached the highest levels to date. Below are major highlights of the year's activities.

Project Interphase (PI) '93 completed its 24th year. There were 59 students in the program, representing 18 states and Puerto Rico. The curriculum included calculus, physics, chemistry, and writing. Several educational and recreational activities complemented the classes. Approximately 78% of the Interphasers satisfied Phase I of the MIT writing requirement in the PI writing class. As a result of PI math, 42% of the students satisfied 18.01 requirements. All but two of them enrolled in 18.02 in the fall '93 term. They had an 80% successful completion rate.

Participation in Program XL continued to increase in 1993/94. Over 60 students participated in XL each term this year; approximately 30% of these were non-underrepresented minorities. The success rate of students passing their corresponding XL subjects continued at about 90%.
The use of Tutorial Services continued to grow. OME hired approximately 156 graduate and upper-class tutors, of whom 18 were assigned primarily to Program XL. The roster of tutors included 28% minority students, 25% internationals, and 47% Caucasian Americans. Their dedication helped to make possible the tutorial services statistics below:

<table>
<thead>
<tr>
<th></th>
<th>Fall '91</th>
<th>Spring '92</th>
<th>Fall '93</th>
<th>Spring '94</th>
</tr>
</thead>
<tbody>
<tr>
<td>Users</td>
<td>104</td>
<td>110</td>
<td>296</td>
<td>375</td>
</tr>
<tr>
<td>Tutoring Hours</td>
<td>275</td>
<td>420</td>
<td>904</td>
<td>1,293</td>
</tr>
<tr>
<td>Ind. Study Hours</td>
<td>n/a</td>
<td>n/a</td>
<td>269</td>
<td>371</td>
</tr>
<tr>
<td>Athena Use Hours</td>
<td>n/a</td>
<td>n/a</td>
<td>162</td>
<td>133</td>
</tr>
</tbody>
</table>

Users accessing OME tutoring were Asian (30%), Black (33%), Hispanic/Latino (16%), Native American (1%), Caucasian (13%), and students from other ethnic groups (7%). There were 20 courses represented in the nearly 60 subjects tutored; students were from all class levels.

In January, 68 students enrolled in the engineering design workshop; 60 were applicants for the Second Summer Program. For the summer of '94, 30 of them received assignments as paid engineering interns. MIT faculty volunteered to visit the interns on site and report on the students' experiences. Their visits will take them to interns in 14 of the companies comprising OME's Industrial Advisory Council for Minority Education (IACME). Membership in IACME increased by four new companies in 1993/94, bringing the total of participating companies to 27. Their participatory and financial support have been critical in helping to make the growth in OME programs possible.

The office facilitated partial or full scholarship support for over 40 underrepresented minority students in awards ranging from $1,000 to $26,000 each and totaling more than $300,000.

Distribution of the SPIRIT newsletter went to a readership of nearly 2000, up from 1600 a year ago. The population of students of color served by OME programs numbered some 622, including 230 African American, 360 Hispanic/Latino, and 32 Native American undergraduates.

JUDY JACKSON
RUBÉN MÓRFIN-RAMÍREZ
GAIL-LENORA STATON

RESIDENCE AND CAMPUS ACTIVITIES

It has been a year of change in Residence and Campus Activities (RCA). The report below summarizes the new initiatives and major accomplishments of the past year.

Mediation
A pilot program entitled mediation@mit was organized and funded to make the option of formal mediation available to the MIT student community. Training programs leading to mediation certification have been developed and implemented by MIT staff; this year approximately 60 staff, students, and faculty have been certified.

Dispute Resolution System
A group of staff, faculty, and students have been working to review and, where appropriate, make changes to the dispute resolution/discipline system for students at MIT. We are putting priority on developing more written information on discipline and harassment procedures, so that rulings/findings are not seen as arbitrary.

Discipline and Harassment
RCA staff handled a significant number of disciplinary and harassment cases. These cases included damage to property, vandalism, unauthorized occupancy, theft, slander, and physical assault. The harassment cases included inappropriate attention, unwanted touching and comments, other verbal and written sexual harassment, and harassment via Athena. The sanctions imposed ranged from verbal warnings, restitution for damages, community service, written letters of apology, agreement to stop the behavior, and probation, to removal from housing. A recurring issue this past year has been the occurrence of inappropriate conduct on the part of members of MIT organizations who are not otherwise affiliated with MIT. A report to the faculty was made by Dean Smith of representative cases over the past three years.

RCA staff have assisted in the development of a series of training videos and acted as facilitators in training seminars for handlers of harassment complaints. To date, approximately 1,000 complaint handlers have attended these sessions.
Huntington Hall Dormitory
As part of the attempt to relieve crowding in the dormitory system, 68 rooms were leased from the Massachusetts College of Art in a dormitory located on Huntington Avenue in Boston. Rooms were offered at a significant rent reduction, MBTA passes were subsidized, and ethernet and MIT telephone connections plus an Athena cluster were installed. These efforts to make this an attractive option resulted in 58 students choosing to reside there. While a number of the students reported that the facility and support there were quite good, concerns were expressed about the commute and the safety of the area and building. About half of the students who lived there this past year have chosen to continue in residence for this coming year.

Undergraduate Housing
Crowding of freshmen remained a problem this year. Despite the addition of Huntington Hall to the dormitory system, there were 195 crowded rooms as the fall term began, well above the nominal limits of 165 crowded rooms. The consequence was that over two-thirds of the freshmen lived in crowded conditions. This extreme crowding adversely affected the social and academic lives of the majority of students in campus housing. Crowding made it necessary to deny the vast majority of applications for housing from students who were living off campus or returning to MIT after an absence.

Faculty Resident Program
Professor Kenneth Oye and Ms. Willa Michener resigned as Faculty Residents in East Campus, after having served since 1991. Professor Shigeru Miyagawa of Foreign Languages and Literature has accepted the East Campus Faculty Resident position.

Asian/Asian-American Students
This year, RCA was able to directly impact the development of an Asian student voice on campus. Staff members facilitated the creation of an Asian student video, which presented a variety of Asian students' voices and concerns about living and studying at MIT. A new student group, Asian Student Caucus, was established with the goal of increasing awareness of issues of direct concern to students of Asian heritage.

House Fellows Program
The House Fellows Program, established in 1987 to promote greater interaction and sense of community between students in Institute Houses and MIT faculty members, included 28 House Fellows associated with four undergraduate and two graduate dormitories and nine independent living groups.

Fraternities, Sororities and Independent Living Groups
Alpha Chi Omega Sorority will become the thirty-fifth Independent Living Group with the Institute’s purchase and renovation of a four story building located at 478 Commonwealth Ave. in Boston. Twenty-five members will take occupancy this August providing another housing option for MIT women as the percentage of women in the entering class reaches 40% for the first time.

Student Activities
With the addition of new staff to work with student activities, notable progress has occurred in several areas:

- Working with the Audit Division, a number of aspects of the financial side of student activities have been identified as needing improvement. Changes are underway to improve fiscal accountability, accuracy of reporting and effectiveness of service to student groups.

- A freshman seminar on student leadership was conducted jointly with the Campus Activities Complex staff.

- A new event registration process was developed with CAC and the Campus Police which made it possible to more effectively monitor and document events.

- A relationship was established with the Alumni/ae Association so that there can be better service to the Class Councils.

- Three staff members were TIPS trained in order to provide more alcohol training programs for students. The Alcohol Committee began to review and revise the MIT Alcohol policy, and to explore the implications of the new Mass State alcohol laws.

Talbot House
The year proved successful with Talbot House’s book balanced for the first time since 1987. There were 49 groups using the facility, up from 46 last year, with 917 people visiting the House, up from 856 visitors.
Staff Changes
Additions to the staff included Dr. Margaret Jablonski from Worcester Polytechnic Institute as Associate Dean and Section Head, Linda D'Anna from the Sloan School as Staff Associate for Residence Programs and Eleanor Crawford as UA Staff Accountant. Departing were Eliot Levitt and Sharon Shea.

MARGARET JABLONSKI  NEAL H. DOROW
SUSAN D. ALLEN  ANDREW M. EISENMAN
LINDA D'ANNA  MARY NI
ELEANOR CRAWFORD

ROTC

Captain Michael E. Field retired at the end of this year as commander of the Navy ROTC unit. His service at MIT was marked by outstanding leadership, efficient administration and an unusual understanding of the relations between ROTC and the Institute.

The ROTC Committee was chaired this year by Professor Alvin W. Drake whose long service to ROTC has been a major source of the strength of these programs. As he steps down as chair, his contribution to ROTC is noted with great appreciation.

Air Force ROTC
The Air Force Reserve Officer Training Corps (AFROTC) program at MIT provides challenging and comprehensive leadership and academic training for students attending MIT, Harvard, Tufts, and Wellesley. We continue to recruit and commission men and women as 2nd lieutenants in the United States Air Force. Year-end enrollment in AFROTC as of June 1994 was as follows:

<table>
<thead>
<tr>
<th></th>
<th>Freshmen</th>
<th>Sophomores</th>
<th>Juniors</th>
<th>Seniors</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIT</td>
<td>9</td>
<td>10</td>
<td>10</td>
<td>14</td>
<td>43</td>
</tr>
<tr>
<td>Harvard</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Tufts</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Wellesley</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>12</td>
<td>12</td>
<td>16</td>
<td>57</td>
</tr>
</tbody>
</table>

Special cadet activities included a Freshman Orientation Program emphasizing Air Force knowledge, physical fitness, and drill; an Air Force Dining-In, a formal dinner with guest speaker; and the Tri-Service Military Ball, parade, awards ceremony, and commissioning ceremony at the USS Constitution.

- In the fall term, Professors Sapolsky and Posen lectured and Colonel Borah and Mr. Lindley led the recitations for 17.471, American National Security Policy, to 33 students (18 were non-AFROTC).

- Detachment 365 sponsored a field day at MIT for cadets from other detachments in the surrounding area.

- The Air Force approved delays in entering active duty to pursue advanced degrees for six MIT graduates and one Harvard graduate. Two of the individuals were Von Karman scholarship winners.

- Fourteen MIT cadets received commissions as 2nd lieutenants on 27 May 1994. Secretary of the Air Force, Dr. Sheila Widnall presided over the ceremony. One Tufts and one Harvard cadet were commissioned on 21 May 1994 and 8 June 1994, respectively.

- The AFROTC program provided MIT cadets with over $673,670 for tuition for AY 93/94.

COLONEL STEVE B. BORAH

Army ROTC
The year was an extremely active and productive one for the Army Program.
Enrollment
Over the academic year, a total of 80 students participated in our program, and at year's end, 63 of those students were still enrolled. Of the 63 Cadets, 9 (14%) were females.

<table>
<thead>
<tr>
<th></th>
<th>Freshmen</th>
<th>Sophomores</th>
<th>Juniors</th>
<th>Seniors</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIT</td>
<td>11</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>23</td>
</tr>
<tr>
<td>Harvard</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>22</td>
</tr>
<tr>
<td>Tufts</td>
<td>4</td>
<td>1</td>
<td>7</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Wellesley</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>8</td>
<td>17</td>
<td>14</td>
<td>63</td>
</tr>
</tbody>
</table>

Of the 23 MIT students enrolled, 19 are currently recipients of Army ROTC scholarships. These scholarships pay 80% of tuition and 100% of fees; provide a monthly allowance of $100; and contribute a one-a-year textbook allowance of $450.

Commissions
This year the Army ROTC Department commissioned 14 new second lieutenants, four of whom were from MIT. Of the 14, two are entering graduate school, ten will be reporting to active duty, and two are serving in the Army Reserve.

Extracurricular Activities
- Brigadier General Gerald C. Brown, Director of Environmental Programs for the U.S. Army was the guest speaker at the Annual Tri-Service Awards Banquet sponsored by Army ROTC.
- Army ROTC also participated in the Military Ball, athletic competitions, and the Tri-Service Commissioning Ceremony at the USS Constitution.
- Cadets trained voluntarily at Fort Benning, GA (Airborne); Ft. Campbell, KY (Air Assault); and other U.S. installations (troop leadership).
- Participation continued strong in the MIT Pershing Rifles Company, a group of both ROTC and non-ROTC students dedicated to the pursuit of military tactical excellence and patriotism.
- The Paul Revere Battalion hosted a one day visit by the Brigade Commander, Colonel Raymond J. Miller.

LIEUTENANT COLONEL BUCKNER M. CREEL IV

Navy ROTC
The Naval Reserve Officers Training Corps (NROTC) program at MIT provides challenging and comprehensive leadership and academic training for students attending MIT, Harvard, and Tufts. In the 1993-94 Academic Year, a total of 33 graduating men and women were commissioned. Program enrollment just prior to June commencement was:

<table>
<thead>
<tr>
<th></th>
<th>Freshmen</th>
<th>Sophomores</th>
<th>Juniors</th>
<th>Seniors</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIT</td>
<td>7</td>
<td>11</td>
<td>13</td>
<td>14</td>
<td>45</td>
</tr>
<tr>
<td>Harvard</td>
<td>4</td>
<td>6</td>
<td>10</td>
<td>15</td>
<td>35</td>
</tr>
<tr>
<td>Tufts</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>19</td>
<td>27</td>
<td>34</td>
<td>91</td>
</tr>
</tbody>
</table>

The Navy's financial assistance totaled approximately $1.6 million for the year, including about $800,000 for MIT students. Enrollment has declined to 91 from the 112 reported last year. Primarily, the decrease stems from a reduced number of NROTC scholarships granted nationwide for the class of '97.

Activities
Annual activities included:
- Freshman Orientation
- Marine Corps Birthday and Tri-Service Balls
• Dining In

• Tri-Service Commissioning Ceremony at the USS Constitution. The Honorable Dr. Sheila E. Widnall, Secretary of the Air Force served as the guest speaker for commissioning.

• Military Excellence Competitions at Cornell, Holy Cross and Villanova. In each event, the Consortium was highly successful both in drill and physical competition.

• Community service projects in Boston.

The midshipmen are participating in summer cruises in Japan, Korea, and Australia, in foreign navies of France and Tunisia, and with U. S. Navy units off the coasts of Bosnia and Somalia. This year, women midshipmen are assigned to destroyers, aircraft carriers, and aviation squadrons.

CAPTAIN MICHAEL E. FIELD

UNDERGRADUATE ACADEMIC AFFAIRS

For UAA, 1993-94 was a year of initiative and achievement on several fronts. What follows is a brief summary of our activities in several areas, focused on change and innovation. A comprehensive account is contained in UAA’s Annual Report for 1993-94, available on request from Dean Travis Merritt.

Academic Advising and Support to Undergraduates

The Freshman advising system enlisted over 200 Advisors and more than 250 Associate Advisors. Plans have been made for a modified system for 1994-95 to meet the needs of advisees not enrolled in Freshman Advisor Seminars. In addition to Seminar-Based Advising (expanded to accommodate up to 1000 freshman), the new system will include Cluster Advising (serving heterogeneous groups of 3 to 5 students) and a smaller version of Residence-Based Advising for dormitory residents.

The Associate Advisors Steering Committee provided:

• workshops and handouts on resume writing and job interviewing

• the services of 90 upperclass mentors, representing all academic departments, to counsel freshmen in their choice of majors

• a more systematic nomination and award process for recognizing outstanding Associate Advisors

Curriculum Support and Innovation

Activities in support of the curriculum included:

• studies of the predictive capacity of the Pre-calculus Math Diagnostic for entering freshmen

• increased activity in support of classrooms, providing support to the Faculty Classroom Advisory Committee and participating on the interdepartmental task force for better classrooms

• working closely with the Physics department and the Registrar’s office to accommodate the registration and scheduling needs of the new version of 8.01, to be introduced in Fall 1994

• studies of when students take the General Institute Requirements and how they utilize Advanced Placement and Advanced Standing

• conducting further experimentation with alternative forms of the Freshman Performance Evaluation process, leading to a full-scale trial of a revised version in 1994-95

• inviting the Associate Deans of Science and Engineering to host this year’s series of core recitation instructors’ lunches

• forming a group on the first year core, which brings together for weekly informal conversation a number of deans and key faculty members concerned with the freshman academic program.
Teaching and Faculty Development (TFD)
The TFD program:

- offered a full scale program of classroom videotaping plus consultative review by Dr. Daniel Goroff from Harvard’s Bok Center. This service was utilized by 45 faculty and other teaching staff.

- presented a 14-part IAP version of the “Even Better Teaching at MIT” series which was heavily attended.

Educational Studies and Research
There were two major activities conducted during the year:

- Undergraduate Academic Dishonesty at MIT, a report based on detailed surveys of faculty, TA, and undergraduate student opinion and experience was completed and circulated. The report’s conclusions about the causes of dishonesty and suggestions for improving the climate for academic integrity have been referred to a working group to recommend implementation.

- The Class of 1994 Senior Survey asks graduating seniors about their undergraduate experience at MIT, and their assessment of it, with a view toward identifying areas which need improvement. Responses were received from 43% of the seniors. The results are being processed and will be available next fall.

Undergraduate Research Opportunities Program
This has been another strong year for Undergraduate Research Opportunities Program (UROP) as participation and satisfaction levels remained high. Last year’s UROP survey has given useful guidance for enhancing the quality of the UROP experience.

Changes in the U.S. Government’s research accounting policy threatened to more than double the cost of UROP stipends. These stipends became subject to charges for indirect costs and employee benefits, effective July 1, 1994. A number of actions helped to reduce the impact of these changes. These actions resulted from the serious concern and effective actions of students, faculty and the administration.

- Stipends paid out of UROP funds will be charged employee benefits only, not indirect costs.

- The Employee Benefits rate for undergraduate research wages was reduced from 43.5% to 6.5%.

- The Provost committed $1M to reimburse faculty supervisors for overhead and EB payments on research-funded stipends for Summer 1994.

The results of these initiatives and adjustments is that the number of paid UROP participants for Summer 1994 stabilized at about 900 rather than suffering a more substantial decline from the previous summer’s 1092.

Independent Activities Period
Independent Activities Period (IAP) ’94 continued the trend of recent years by modestly increasing the numbers of large-scale and for-credit activities offered. There was a significant gap between the number of students wishing to enroll in subjects for credit and the number who could be accommodated in those available; nearly a thousand were turned away because of enrollment limits.

Other highlights of IAP ’94 were:

- a sharp rise in substantial IAP participation by Freshmen

- expansion of The Verbal Institute to two dozen activities concerned with writing and speaking

- a more diversified and seriously focused version of Charm School

- a major two-day conference on Technology and Employment, which attracted more than 300 participants

- fifteen students working full-time in Cambridge’s elementary schools as IAP fellows under the sponsorship of the MIT Public Service Center

The Writing Requirement and the Writing Initiative
In order to foster instruction in clear, effective writing, UAA undertook to increase the opportunities for students to engage in and be instructed in writing and speaking by:
• organizing satellite writing subjects connected to specific engineering subjects. This year seven sections were offered; next year the Program in Writing and Humanistic Studies will offer 15 sections. UAA coordinated the selection of the Graduate Writing Fellows who taught these sections, conducted the training sessions during the fall 1993 term and IAP 1994, supervised and provided logistic and pedagogical support to the Fellows during the spring 1994 term.

• sponsoring the Verbal Institute during IAP. The Institute offered over 20 different activities connected to instruction in writing and speaking. One of these, "A Little Writing Anyone?", explored ways to inject writing as an integral part of learning in any subject in the undergraduate curriculum.

• jointly sponsoring with the Program in Writing and Humanistic Studies a new IAP writing subject, 21W 783, "Experimentation, Expression, and Experience: An Intensive Writing Workshop".

**Residence/Orientation Period**

At the conclusion of R/O '92, UAA staff conducted a comprehensive exit survey of freshmen to determine levels of attendance at and satisfaction with various aspects and individual events. The conclusion for academic orientation was that concrete, practical information and guidance about academic programs and choices was most important. In accordance with these findings, the UAA staff and R/O '93 Committee emphasized activities with factual utility and eliminated others which were primarily for entertainment.

**The MIT Colloquium/TeamWorks**

One of the outcomes of the 1992-93 Colloquium on academic integrity was the creation of TeamWorks, a student-run and UAA-supported initiative to make collaboration a stronger component in learning. This group organized team-study groups in four freshman core subjects, with promising results.

**Staff Changes**

Ida Faber joined the staff as Staff Assistant replacing Stephanie Bartling. Also departing were Claude Poux and Maureen Horgan.

<table>
<thead>
<tr>
<th>TRAVIS R. MERRITT</th>
<th>ALICE M. E. LAPIERRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARGARET E. DEVINE</td>
<td>ALBERTA G. LIPSON</td>
</tr>
<tr>
<td>MARGARET S. ENDERS</td>
<td>NORMA G. MCGAVERN</td>
</tr>
<tr>
<td>MARY Z. ENTERLINE</td>
<td>JEFFREY A. MELDMAN</td>
</tr>
<tr>
<td>DONNA L. FRIEDMAN</td>
<td>LESLIE C. PERELMAN</td>
</tr>
<tr>
<td>IDA FABER</td>
<td>DEBBIE H. SHOAP</td>
</tr>
<tr>
<td>ELIZABETH KOWAL</td>
<td>BONNIE J. WALTERS</td>
</tr>
</tbody>
</table>
COMMITTEE ON GRADUATE SCHOOL POLICY (CGSP)

During the past year a major portion of the CGSP's attention was directed to evaluation of proposals for several new masters degree programs. The first of these resulted from the Sloan School's proposal, introduced in the previous year, to offer a masters degree in which the thesis would be optional rather than an absolute requirement. Following extensive discussion with the CGSP, the Sloan School proposed the establishment of a new masters degree program which would lead to the Masters of Business Administration (M.B.A.) degree and which would have no thesis requirement. In lieu of a thesis, the proposal called for a program with a large component of written and oral reporting coupled with extensive team and individual project work. Because this would be the first graduate degree program in many years to have no required thesis, the proposal received particularly intense review and discussion by the CGSP. (Currently, the only other graduate program at MIT without a formal thesis requirement is the Master of Science degree offered through the Chemical Engineering Department's Practice School.) Following this review, the M.B.A. degree proposal was approved by the CGSP, and subsequently by the MIT faculty and Corporation. Beginning with the 1994 fall term, the Sloan School will offer both the existing S.M. (with thesis) and M.B.A. degree programs.

The previous year's creation of a new degree, the Master of Engineering (M.Eng.), and its implementation in the Department of Electrical Engineering and Computer Science, led as expected to consideration of M.Eng. programs in several other engineering departments. The first of these, an M.Eng. in Ocean Engineering, was proposed in that department's Program in Marine Environmental Engineering, and was approved by the CGSP. A proposal for an M.Eng. in Civil and Environmental Engineering was also reviewed by the CGSP; however, formal action was deferred to the coming year so that the department could clarify the nature of the proposal's thesis component. A preliminary report was also received regarding an M.Eng. proposal which is expected from the Department of Aeronautics and Astronautics early in the coming year. Each of these new M.Eng. programs is characterized by its emphasis on preparation for engineering practice, one-year duration, and limited dependence on sponsored research for student support. None of the new programs was proposed as a fifth-year extension of the undergraduate program as was done in the previous year with the EECS version of the M.Eng.

During debate on the M.Eng. programs a question arose concerning the need for faculty and Corporation approval of each individual program since such approval of the generic M.Eng. degree had already been obtained. Following discussion of this issue with the Faculty Policy Committee (FPC), it was determined that these higher levels of approval were necessary, but that the FPC might act on behalf of the faculty whenever it was determined that a particular departmental proposal introduced no significant deviation from existing programs.

Among other miscellaneous items of business, the CGSP considered and rejected a proposal to allow a temporary (one term) use of pass/fail grading in one department. A proposal for direct admission to the Technology and Policy Program was also considered and rejected.

The CGSP conducted its usual reviews of degree lists and end-of-term grades, and issued a number of Dean's warnings and denials of further registration.

My colleagues in the Office of the Dean of the Graduate School (ODGS) wish to express our thanks and appreciation to members of the CGSP for their service during the past year. A special note of thanks is extended to the following members who will be replaced in the coming year: Eduardo Kausel (Civil and Environmental Engineering) replaced by Joseph Sussman, Julian Beinart (Architecture) replaced by Leslie Norford, Glenn Berchtold (Chemistry) replaced by Dietmar Seyferth, William Quinn, Jr. (Brain and Cognitive Sciences
replaced by Gerald Schneider, Peter Temin (Economics) replaced by Olivier Blanchard, and Donald Blackmer (Political Science) replaced by Nazli Choucri. I would also like to thank the departmental graduate administrators who work closely and so effectively with the ODGS and the official CGSP members. Monthly luncheon meetings of these administrators, organized this year by their chair, Linda Peterson (MAS), and secretary, Cynthia Stewart, have again been extremely helpful to the ODGS.

RECRUITMENT AND OUTREACH
The Minority Summer Research Program (MSRP) brought its eighth consecutive group of interns to MIT for ten weeks beginning in June 1994. Unfortunately, funding constraints forced us to limit the attendance to twenty students, a significant reduction from last year's penultimate figure of 28. Nine interns were placed in the School of Engineering, continuing the recent expansion of interest by that school. The funding constraints were occasioned by the scheduled termination of several long-term grants which had been established in the early days of the program. It is clear that the continued health and expansion of this highly successful program depends critically on the establishment of a solid base of long-term funding. Initiatives in this regard were underway at the end of this past year and will be expanded in the early part of the coming year.

As noted in the previous year's report, the Visiting Faculty Program for Historically Black Colleges and Universities was determined to have been ineffective in meeting its objectives; consequently, an initiative was undertaken to transfer support from the program's sponsor, the Coca-Cola Company, to the MSRP.

The Minority Mentorship Program, which has been reported on in previous reports, continued to provide meaningful guidance and practical advice regarding the process of applying to, financing, and navigating through the entire graduate education process.

Continuing an aggressive recruitment strategy to help departments increase their minority applicant pool, the recruiting staff pursued their well-established four-point process: (1) A preadmissions phone-a-thon, facilitated by members of minority graduate clubs, targeted likely applicants who had been identified through recruiting trips; (2) A post-admissions phone-a-thon, again facilitated by current minority graduate students, and targeting every student of color who has been offered admission; (3) Target marketing, involving a variety of personalized mailings, personalized contacts by office staff and departmental representatives, directed brochures, and similar individually focused communications; and (4) Faculty travel and contacts, accomplished by facilitating faculty travel to targeted schools to speak with honors classes, science and engineering societies, and participants in special programs.

This program of enhanced outreach again showed some positive outcomes in the past year. In particular, the 13.2% increase in minority graduate student enrollment, from 190 in the previous year to 215 in the past year, was most encouraging and brought that enrollment to its highest absolute level ever and its highest percentage level since 1977. Nonetheless, these encouraging signs are tempered by the realization that the percentage level is still far below our desired levels.

INDIVIDUAL ACTIVITIES
During the past year Dean Perkins completed his tenure as president of the Association of Graduate Schools (AGS) in the Association of American Universities (AAU) and continued to serve on the AGS Executive Committee as past president. He was also appointed to an ad hoc AAU committee which will conduct a review of policies, practices and issues related to the role played by postdoctoral fellows in the nation's research universities.

Associate Dean Isaac Colbert worked closely with the Registrar's office in its design of a major, new, computerized Student Information System which is ultimately expected to change significantly the ODGS's processing of graduate awards and appointments. He also
continued to be active in MIT's new Council on Family and Work as well as a number of external community service organizations. Of particular significance was his involvement as a key player in a major, Institute-wide reengineering effort which was initiated during the past year. It is expected that his involvement in this critically important activity will increase significantly in the coming year.

The ODGS was particularly pleased to welcome Assistant Dean Margaret Daniels Tyler back from a one-year leave during which she served as Dean in Residence at the Council of Graduate Schools (CGS) in Washington, D.C. As a direct result of this special service role Dean Tyler authored a CGS monograph entitled, *Enhancing the Minority Presence in Graduate Education V: Summer Research Opportunity Programs*.

OTHER ISSUES AND ACTIVITIES
The ODGS continued its role, jointly with the Provost's Office, in organizing the annual Workshop for New Faculty and Graduate Teaching Assistants. This day-long program, which occurs at the beginning of the fall term each year, has proven to be an effective mechanism for introducing new members of the teaching staff to their new responsibilities. This past year's workshop was attended by more than 200 participants, the largest attendance in the twelve-year history of the workshop. Special thanks are due Dr. Jeffrey Meldman, Associate Dean for Undergraduate Academic Affairs, and Jackie Sciacca, Fellowship Coordinator in the ODGS, for their pivotal role in creating and sustaining the workshop since its inception.

In last year's report, we commented on a multi-million dollar judgment issued by the Internal Revenue Service (IRS) against MIT for our tax treatment of the stipends and tuition scholarships received by graduate RAs and TAs in calendar years 1985 and 1986, and noted that an appeal of that judgment was pending at year's end. The appeals officers findings were subsequently issued during the past year, and concluded that much of the original judgment against MIT was without merit. However, rather than revoking those parts of the judgment, the entire case was sent back to the original investigating office for a reevaluation. Thus, the entire case remains essentially unresolved.

We are pleased to note that the National Science Foundation (NSF) revised its stance regarding the use of partial RAs and TAs in making up the tuition shortfall which is associated with the support of NSF predoctoral fellows. In previous years we had been allowed to apply only the tuition scholarship portion of a partial RA or TA to the shortfall; however, during the past year the NSF gave permission to use some or all of the RA/TA stipend for that purpose as well. This decision permitted us to eliminate the "windfall" stipend supplement about which we expressed concern in our 1993 report.

GRADUATE SCHOOL STATISTICS
Important statistics concerning the Graduate School are presented in Tables I-IV and Figures I-III, which follow. The format and content of these figures and tables are identical to those which have been presented in recent years.

The enrollment figures in Table I show no major changes from the previous year. The total graduate student enrollment increased by only five (5) students, but still reached its highest level ever. However, as noted in Table V and Figures I-III, there were small but significant increases in the enrollment of women and foreign national graduate students and a somewhat larger and encouraging increase in the minority enrollment. As noted earlier in this report, the latter reached its highest absolute level (215) ever and its second highest percentage level (4.3%). The women and minority enrollment figures are encouraging but still far from the levels to which we aspire.

The total number of graduate applications (Table III) was almost identical to the figure for the preceding year (10,677 vs. 10,685) and reflects an end to several years of substantial
growth in applications. These figures will be closely watched in the coming years to see if this cessation of growth reflects a significant change or is a one-time anomaly.

Financial support for graduate students in the form of RAs, TAs, and fellowships (including billings to outside sponsors) are summarized in Table III. These data an increase of 2.7% in tuition support from the previous year, an increase which is substantially less than the 5.6% increase in MIT's tuition. This failure to keep pace with tuition is of considerable concern and will be watched carefully in the coming year to see if it reflects a fundamental change in the availability in graduate student support. The stipend figures presented in Table III represent an increase of 3.8% over the previous year; this increase is consistent with measures of the cost-of-living increase for the same period.

FRANK E. PERKINS
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<tr>
<th>CATEGORY</th>
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<th>MINORITY</th>
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<th>NON-RESIDENT</th>
<th>TOTAL</th>
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<tr>
<td>TOTAL GRADUATE ENROLLMENT</td>
<td>1755</td>
<td>1177</td>
<td>215</td>
<td>1339</td>
<td>136</td>
<td>5024</td>
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<td>CATEGORY AS % OF TOTAL</td>
<td>34.9%</td>
<td>23.4%</td>
<td>4.3%</td>
<td>26.7%</td>
<td>2.7%</td>
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</tr>
</tbody>
</table>

*Minority" refers to underrepresented minorities (i.e., Black Americans, Puerto Ricans, Mexican Americans, and Native Americans).

*New* refers to new graduate students enrolled for the first time in the Graduate School.

*Non-Resident* refers to students who are in non-resident doctoral dissertation status.

**TABLE I: GRADUATE ENROLLMENT STATISTICS, FALL 1993**
<table>
<thead>
<tr>
<th>CATEGORY OF SUPPORT</th>
<th>NUMBER OF STUDENTS (ACTUAL)</th>
<th>NUMBER OF STUDENTS (EFS)</th>
<th>TUITION FALL TERM</th>
<th>TUITION SPRING TERM</th>
<th>STIPEND FALL TERM</th>
<th>STIPEND SPRING TERM</th>
<th>TOTAL ACADEMIC YEAR SUPPORT</th>
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<tr>
<td>Research Assistantships</td>
<td>2,733</td>
<td>2,021</td>
<td>19,300</td>
<td>19,093</td>
<td>11,466</td>
<td>11,344</td>
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<td>Teaching Assistantships*</td>
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<td>4,025</td>
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<td>Federal Fellowships/Traineeships</td>
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<td>439</td>
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<td>218</td>
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<td>MIT Endowed Support (ODGS)</td>
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<td>457</td>
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<td>100</td>
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<td>MIT General Support</td>
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<td>Foundation Fellowships</td>
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<td>Billed by MIT to Outside Sponsors**</td>
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<td>19,566</td>
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</table>

Note: Many students receive partial support from one or more sources. Therefore, the total number of students receiving support from any source may exceed the total number of graduate students. The term "EFS" refers to an equivalent number of fully supported students, and is computed by dividing the total tuition support by the academic year tuition of $19,000 per student.

* includes Instructor G's
** includes students enrolled in MIT/WHOI Joint Program
*** does not equal total of above numbers because some students receive funding from more than one source

TABLE II: SOURCES AND AMOUNTS OF GRADUATE STUDENT SUPPORT, 1993-94 ACADEMIC YEAR

(DOLLAR AMOUNTS REPRESENTED IN THOUSANDS)
<table>
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<th>SCHOOL OF ARCHITECTURE &amp; PLANNING</th>
<th>NUMBER OF APPLICANTS</th>
<th>NUMBER ADMITTED</th>
<th>RATIO ADMIT/APPL</th>
<th># PLANNING TO REGISTER</th>
<th>RATIO REG/ADMIT</th>
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<td>0.33</td>
<td>56</td>
<td>0.43</td>
</tr>
<tr>
<td>Earth, Atmospheric &amp; Planetary Sciences</td>
<td>190</td>
<td>50</td>
<td>0.26</td>
<td>29</td>
<td>0.58</td>
</tr>
<tr>
<td>Mathematics</td>
<td>352</td>
<td>43</td>
<td>0.12</td>
<td>16</td>
<td>0.37</td>
</tr>
<tr>
<td>Physics</td>
<td>681</td>
<td>104</td>
<td>0.15</td>
<td>39</td>
<td>0.38</td>
</tr>
<tr>
<td>WHITAKER COLLEGE</td>
<td>38</td>
<td>5</td>
<td>0.13</td>
<td>4</td>
<td>0.80</td>
</tr>
<tr>
<td>Toxicology</td>
<td>38</td>
<td>5</td>
<td>0.13</td>
<td>4</td>
<td>0.80</td>
</tr>
<tr>
<td>HEALTH SCIENCES &amp; TECHNOLOGY</td>
<td>30</td>
<td>13</td>
<td>0.43</td>
<td>10</td>
<td>0.77</td>
</tr>
<tr>
<td>INSTITUTE TOTALS</td>
<td>10677</td>
<td>2416</td>
<td>0.23</td>
<td>1179</td>
<td>0.49</td>
</tr>
</tbody>
</table>

* Applicants to these programs who are subsequently admitted are included in a departmental admissions total. For example, applicants to the Real Estate Development Program are admitted to the Department of Architecture or the Department of Urban Studies and Planning, and are tabulated in the admissions statistics of one or the other of those two departments.

TABLE III: GRADUATE APPLICATIONS AND ADMISSIONS STATISTICS, FALL 1993
### NUMBER OF INDICATED DEGREES

<table>
<thead>
<tr>
<th>School</th>
<th>Ph.D</th>
<th>Sc.D</th>
<th>Engineers</th>
<th>Masters</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SCHOOL OF ARCHITECTURE &amp; PLANNING</strong></td>
<td>13</td>
<td>-</td>
<td>-</td>
<td>159</td>
<td>172</td>
</tr>
<tr>
<td>Architecture</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>80</td>
<td>81</td>
</tr>
<tr>
<td>Media Arts and Sciences</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>18</td>
<td>24</td>
</tr>
<tr>
<td>Urban Studies &amp; Planning</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>61</td>
<td>67</td>
</tr>
<tr>
<td><strong>SCHOOL OF ENGINEERING</strong></td>
<td>199</td>
<td>29</td>
<td>31</td>
<td>681</td>
<td>940</td>
</tr>
<tr>
<td>Aeronautics &amp; Astronautics</td>
<td>14</td>
<td>2</td>
<td>1</td>
<td>68</td>
<td>85</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>19</td>
<td>2</td>
<td>0</td>
<td>31</td>
<td>52</td>
</tr>
<tr>
<td>Civil &amp; Environmental Engineering</td>
<td>17</td>
<td>4</td>
<td>1</td>
<td>101</td>
<td>123</td>
</tr>
<tr>
<td>Electrical Eng &amp; Computer Science</td>
<td>63</td>
<td>10</td>
<td>9</td>
<td>240</td>
<td>322</td>
</tr>
<tr>
<td>Materials Science &amp; Engineering</td>
<td>25</td>
<td>6</td>
<td>0</td>
<td>35</td>
<td>66</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>31</td>
<td>2</td>
<td>1</td>
<td>140</td>
<td>174</td>
</tr>
<tr>
<td>Nuclear Engineering</td>
<td>17</td>
<td>3</td>
<td>2</td>
<td>23</td>
<td>45</td>
</tr>
<tr>
<td>Ocean Engineering</td>
<td>13</td>
<td>0</td>
<td>17</td>
<td>43</td>
<td>73</td>
</tr>
<tr>
<td><strong>SCHOOL OF HUMANITIES &amp; SOCIAL SCIENCES</strong></td>
<td>45</td>
<td>-</td>
<td>-</td>
<td>8</td>
<td>53</td>
</tr>
<tr>
<td>Economics</td>
<td>28</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>28</td>
</tr>
<tr>
<td>Linguistics &amp; Philosophy</td>
<td>8</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Political Science</td>
<td>9</td>
<td>-</td>
<td>-</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td>Science, Technology &amp; Society</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>SCHOOL OF MANAGEMENT</strong></td>
<td>13</td>
<td>-</td>
<td>-</td>
<td>352</td>
<td>365</td>
</tr>
<tr>
<td><strong>SCHOOL OF SCIENCE</strong></td>
<td>204</td>
<td>1</td>
<td>-</td>
<td>22</td>
<td>227</td>
</tr>
<tr>
<td>Applied Biological Sciences</td>
<td>3</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Biology</td>
<td>34</td>
<td>0</td>
<td>-</td>
<td>1</td>
<td>35</td>
</tr>
<tr>
<td>Brain &amp; Cognitive Sciences</td>
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<td>-</td>
<td>-</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Chemistry</td>
<td>46</td>
<td>0</td>
<td>-</td>
<td>3</td>
<td>49</td>
</tr>
<tr>
<td>Earth, Atmospheric &amp; Planetary Sciences</td>
<td>27</td>
<td>1</td>
<td>-</td>
<td>6</td>
<td>34</td>
</tr>
<tr>
<td>Mathematics</td>
<td>28</td>
<td>0</td>
<td>-</td>
<td>4</td>
<td>32</td>
</tr>
<tr>
<td>Physics</td>
<td>57</td>
<td>0</td>
<td>-</td>
<td>8</td>
<td>65</td>
</tr>
<tr>
<td><strong>WHITAKER COLLEGE</strong></td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Toxicology</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td><strong>HEALTH SCIENCES &amp; TECHNOLOGY</strong></td>
<td>6</td>
<td>2</td>
<td>-</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td><strong>TOTAL GRADUATE DEGREES</strong></td>
<td>483</td>
<td>32</td>
<td>31</td>
<td>1226</td>
<td>1772</td>
</tr>
</tbody>
</table>

These figures are the number of degrees academically cleared by the Committee on Graduate School Policy. They include 35 graduate degrees awarded through the MIT-Woods Hole Oceanographic Institution Joint Program as follows: 19 PhD's (5 in Engineering, 14 in Science), 5 Engineer's Degrees, and 11 Master's Degrees (8 in Engineering, 3 in Science).

**TABLE IV: GRADUATE DEGREES AWARDED IN ACADEMIC YEAR 1993-94**
<table>
<thead>
<tr>
<th>ACADEMIC YEAR</th>
<th>NUMBER OF WOMEN</th>
<th>PERCENT WOMEN</th>
<th>NUMBER OF FOREIGN NAT.</th>
<th>PERCENT FOREIGN NAT.</th>
<th>NUMBER OF MINORITIES</th>
<th>PERCENT MINORITIES</th>
<th>TOTAL ENROLLMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>304</td>
<td>9.1%</td>
<td>927</td>
<td>27.9%</td>
<td>108</td>
<td>3.2%</td>
<td>3,328</td>
</tr>
<tr>
<td>1974</td>
<td>318</td>
<td>9.5%</td>
<td>954</td>
<td>28.4%</td>
<td>121</td>
<td>3.6%</td>
<td>3,358</td>
</tr>
<tr>
<td>1975</td>
<td>405</td>
<td>11.7%</td>
<td>970</td>
<td>28.0%</td>
<td>151</td>
<td>4.4%</td>
<td>3,468</td>
</tr>
<tr>
<td>1976</td>
<td>487</td>
<td>13.5%</td>
<td>1,037</td>
<td>28.8%</td>
<td>155</td>
<td>4.3%</td>
<td>3,603</td>
</tr>
<tr>
<td>1977</td>
<td>546</td>
<td>14.5%</td>
<td>1,059</td>
<td>28.1%</td>
<td>178</td>
<td>4.7%</td>
<td>3,774</td>
</tr>
<tr>
<td>1978</td>
<td>559</td>
<td>14.6%</td>
<td>1,151</td>
<td>30.1%</td>
<td>157</td>
<td>4.1%</td>
<td>3,824</td>
</tr>
<tr>
<td>1979</td>
<td>606</td>
<td>15.4%</td>
<td>1,145</td>
<td>29.0%</td>
<td>147</td>
<td>3.7%</td>
<td>3,944</td>
</tr>
<tr>
<td>1980</td>
<td>684</td>
<td>16.5%</td>
<td>1,219</td>
<td>29.4%</td>
<td>150</td>
<td>3.6%</td>
<td>4,146</td>
</tr>
<tr>
<td>1981</td>
<td>779</td>
<td>17.8%</td>
<td>1,283</td>
<td>29.3%</td>
<td>174</td>
<td>4.0%</td>
<td>4,384</td>
</tr>
<tr>
<td>1982</td>
<td>828</td>
<td>18.2%</td>
<td>1,347</td>
<td>29.7%</td>
<td>140</td>
<td>3.1%</td>
<td>4,541</td>
</tr>
<tr>
<td>1983</td>
<td>856</td>
<td>19.1%</td>
<td>1,418</td>
<td>31.6%</td>
<td>145</td>
<td>3.2%</td>
<td>4,489</td>
</tr>
<tr>
<td>1984</td>
<td>914</td>
<td>19.7%</td>
<td>1,439</td>
<td>31.1%</td>
<td>143</td>
<td>3.1%</td>
<td>4,631</td>
</tr>
<tr>
<td>1985</td>
<td>981</td>
<td>20.6%</td>
<td>1,449</td>
<td>30.5%</td>
<td>141</td>
<td>3.0%</td>
<td>4,757</td>
</tr>
<tr>
<td>1986</td>
<td>981</td>
<td>19.9%</td>
<td>1,658</td>
<td>33.7%</td>
<td>139</td>
<td>2.8%</td>
<td>4,920</td>
</tr>
<tr>
<td>1987</td>
<td>987</td>
<td>19.8%</td>
<td>1,497</td>
<td>30.1%</td>
<td>144</td>
<td>2.9%</td>
<td>4,979</td>
</tr>
<tr>
<td>1988</td>
<td>929</td>
<td>19.2%</td>
<td>1,441</td>
<td>29.8%</td>
<td>154</td>
<td>3.2%</td>
<td>4,832</td>
</tr>
<tr>
<td>1989</td>
<td>963</td>
<td>20.0%</td>
<td>1,498</td>
<td>31.1%</td>
<td>159</td>
<td>3.3%</td>
<td>4,822</td>
</tr>
<tr>
<td>1990</td>
<td>1,064</td>
<td>21.7%</td>
<td>1,628</td>
<td>33.2%</td>
<td>168</td>
<td>3.4%</td>
<td>4,909</td>
</tr>
<tr>
<td>1991</td>
<td>1,092</td>
<td>22.0%</td>
<td>1,674</td>
<td>33.7%</td>
<td>155</td>
<td>3.1%</td>
<td>4,967</td>
</tr>
<tr>
<td>1992</td>
<td>1,155</td>
<td>23.0%</td>
<td>1,711</td>
<td>34.1%</td>
<td>190</td>
<td>3.8%</td>
<td>5,019</td>
</tr>
<tr>
<td>1993</td>
<td>1,177</td>
<td>23.4%</td>
<td>1,755</td>
<td>34.9%</td>
<td>215</td>
<td>4.3%</td>
<td>5,024</td>
</tr>
<tr>
<td>TOTALS</td>
<td>16,615</td>
<td>18.1%</td>
<td>28,260</td>
<td>30.8%</td>
<td>3,234</td>
<td>3.5%</td>
<td>91,719</td>
</tr>
</tbody>
</table>

TABLE V: WOMEN, FOREIGN NATIONAL AND MINORITY ENROLLMENT, AY1973 TO AY1993
FIG. I

ENROLLMENT OF GRADUATE WOMEN
AY 1973 - AY 1993

FIG. II

INTERNATIONAL GRADUATE ENROLLMENT
AY 1973 - AY 1993

FIG. III

MINORITY GRADUATE ENROLLMENT
AY 1973 - AY 1993
BACKGROUND
The Lowell Institute School (LIS) was established at MIT in 1903 to provide evening instruction in technical subjects for residents of the Boston area. Today the School continues this tradition by offering subjects in the areas of modern technology which are not readily available at other evening institutions. Entry-level courses require an adequate high school preparation, and the more advanced instruction is geared to the practicing technician who has an Associate degree or equivalent experience.

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

CURRICULUM
During 1993-94, LIS offered 38 different courses in analog and digital electronics, microprocessors, computer literacy, computer aided drafting and circuit board design, engineering drawing, alarm technology, key technologies in optoelectronics, computer networking, and computer programming in BASIC, C, UNIX, and X Windows. In addition to refresher courses in mathematics, calculus was included in the curriculum.

New courses were introduced in PageMaker, Windows, Pascal programming, and advanced calculus.

A summer program was continued this year to respond to the heavy demand for computer instruction. Two hundred thirty-five students enrolled in courses in AutoCAD, PageMaker, computer literacy, the IBM disk operating system, and programming in C, UNIX, and X Window environments.

AFFIRMATIVE ACTION
LIS admitted a total of 936 students to its courses in 1993-94. Of those enrolled, 83 percent successfully fulfilled the certificate requirements. Among those who completed courses were 75 MIT employees. Seven students earned the Certificate in Electronics Technology, five students earned the Certificate in Engineering Drawing, and one student earned the Certificate in Computer Technology. Twenty-one percent of the students were women desiring to enter or to improve their positions in technical fields. The instructing staff of 35 includes two blacks, three Asians, and five women.

SUMMARY
The past academic year has seen LIS continue its program of unique courses which no other Boston area school can match. The high percentage of students who successfully complete their courses indicates that both the subjects offered and the level of instruction are well matched to their needs.

BRUCE D. WEDLOCK
Special Summer Programs

The Summer Session Office administers an extensive series of one- and two-week special programs for professional men and women who wish to keep pace with developments in their fields. This activity has prospered each summer since its initiation in 1950. Current information on subjects and registrations is as follows:

Summer 1992: 1172 registrations in 62 special programs by 1124 individuals
Summer 1993: 1186 registrations in 50 special programs by 1136 individuals

Foreign students comprised approximately 7 percent of this registration.

Regular Students

Graduate students comprise 88 percent of the student body during the summer. The 1993 registration of 3125 students was a decrease from 3188 in 1992.
INTRODUCTION
The Joint Program of the Woods Hole Oceanographic Institution and the Massachusetts Institute of Technology offers doctoral degrees in oceanography and applied ocean science and engineering. Graduate study encompasses virtually all of the basic sciences as they apply to the marine environment: physics, chemistry, geology, geophysics, and biology. Students who choose applied ocean science and engineering may concentrate in the major fields (civil, environmental, mechanical, and electrical), materials science, or oceanographic engineering. More than 160 scientists/faculty from the two institutions participate in the Joint Program.

Since all the faculty involved in the Joint Program are members of an academic department at MIT, their individual accomplishments and awards are reported through those departments. These include Courses I, II, VI, VII, XII and XIII.

ADMISSIONS STATISTICS
There were 215 applicants to the Joint Program for 1994-95 representing a 12 percent increase over last year. Again this year we maintained our high acceptance statistics: 74 percent of all applicants offered admission accepted, giving us the cream of the crop as our entering class. Women comprise 38 percent of the entering class, and one of the new students is an African American.

CURRENT AND PROJECTED ENROLLMENT
Enrollment in the Joint Program stayed at an even level: 144 students. The projected enrollment estimate for September is 162 students, with 18 in Chemical Oceanography, 29 in Marine Geology and Geophysics, 34 in Biological Oceanography, 39 in Applied Ocean Science and Engineering, and 42 in Physical Oceanography.

JOINT PROGRAM GRADUATES
The Joint Program graduated 29 students in 1993-94; of these, 21 received the doctorate, five received the master's degree, four received the engineer's degree, and one received both the master's and engineer's degree. The breakdown by discipline is as follows: Chemical Oceanography (three); Biological Oceanography (three); Marine Geology and Geophysics (five); Physical Oceanography (six); and Applied Ocean Science and Engineering (twelve).

MIT/WHOI JOINT PROGRAM 25TH ANNIVERSARY CELEBRATION
We celebrated our 25th Anniversary October 1-3 with a series of events in Cambridge and Woods Hole. More than 250 attended the opening event held October 1 at the Museum of Science. Eighty-five alumni, almost 25 percent of the total alumni body, were present over the three-day period. On October 2, a symposium entitled "Alumni Perspectives on the Field of Oceanography and Oceanographic Engineering" was held at MIT. The keynote address at the luncheon immediately following the symposium was given by Dr. D. James Baker, Under Secretary of Commerce for Oceans and Atmosphere and Administrator of the National Oceanic and Atmospheric Administration (NOAA). Festivities at Woods Hole included a resolution to formally organize a Joint Program Alumni/ae Association.

SALLIE W. CHISHOLM
The Whitaker College of Health Sciences and Technology (Whitaker College) is a major interdisciplinary academic and research entity at MIT. Several areas of research and teaching that are pertinent to health, both fundamental and applied, have been developed and incorporated into Whitaker College.

Current activities in the Whitaker College include the Harvard/MIT Division of Health Sciences and Technology, the Clinical Research Center, the Division of Toxicology, the Center for Environmental Health Sciences, and Biomedical Imaging and Computation.

We report here on the events and new initiatives of programs that operate within the College core. The activities of the above departments and centers are reported separately.

**BIOLOGICAL IMAGING AND COMPUTATION**

Research in imaging and computer simulation takes place in the Whitaker College Biomedical Imaging and Computation Laboratory (WCBICL). In addition to providing a site for the faculty and research staff associated with this effort, the goal of the laboratory is to encourage faculty, research staff and students in relevant departments to collaborate on basic research in imaging technologies and display methods and in simulating and understanding the interaction of radiation of different types with tissue and bone.

The resources of the laboratory currently include seven SUN Microsystems workstations, two Silicon Graphics workstations, one PC, and two Macintosh computers. All are directly connected to the MIT Campus Network. A variety of peripheral devices are also available.

Under the direction of Professor Jacquelyn Yanch of the Nuclear Engineering Department, the main research focus in the WCBICL over the past year has been in the area of computer simulation of the interaction of radiation with a variety of materials. A number of different projects are underway in this area, all of which have as their ultimate goal the development and improvement of the medical uses of radiation. Projects include the study of beta-particle dosimetry in the treatment of rheumatoid arthritis, the development and testing of an accelerator-based source of neutrons for use in cancer therapy and the modeling of a miniature X-ray source for use in interstitial radiotherapy of brain tumors.

A second research thrust in the WCBICL is in the area of image analysis and image diagnosis. Areas of major interest over the past year include the automated analysis of mammograms, algorithms for detection of shape irregularities in images of synaptic vesicles, and the development of new methods of real-time three-dimensional image display. One project dealing with the simulation of gamma photos in Nuclear Medicine imaging is able to link the two major research areas (imaging and radiation transport simulation) in the lab.

Two efforts at improving scientific communication between WCBICL and the rest of the MIT community and beyond have continued over the past two years. The first of these is a lab open house held during IAP. Ten different research projects are highlighted, data from each being displayed on an individual workstation. A short written description is also available for interested attendees. Over 150 people attended the first open house which has now become an annual event. The third WCBICL open house is scheduled for January 24, 1995.

The second new effort was establishing the lab newsletter called *Particle Transport News*. Five issues of this six-page newsletter have been compiled and distributed to over 300 people. Each issue highlights one of the ongoing research projects in the WCBICL, provides software and hardware information, and "spotlights" one of the students currently working on thesis projects in the lab. These newsletters have been extremely well-received, both within the MIT community and by labs and individual researchers throughout the country. Our sixth issue is scheduled for distribution during IAP, 1995.

A new effort at improving scientific communication between WCBICL and the outside scientific community is currently under the development. A multi-layer page on the World Wide Web (WWW) in which all the
research projects and personnel of the lab are listed and described is scheduled to be up and running in January of 1995. It is expected that the contents of the WWW page will change as research projects proceed and new projects are taken on by individuals in the lab.

The lab currently has 52 registered users consisting of faculty, research staff, graduate students, undergraduate students and visitors from outside MIT who use the resources of the lab remotely. Roughly 30 users are from the Nuclear Engineering Department (NED), 18 are from the Harvard-MIT Division of Health Sciences and Technology (HST) or other parts of the Whitaker College and 14 are from the rest of the MIT community or are remote "visitors."

The WCBICL continues to play an increasingly important role in education, particularly with respect to the Department of Nuclear Engineering and the Harvard-MIT Division of Health Sciences and Technology doctoral programs. Many of the students in these programs conduct thesis research in the lab; the lab is also used for teaching and experimentation in both HST and NED. The HST laboratory projects are designed to provide practical experience in processing physiological data with examples from neurophysiology, cardiology, and two-dimensional image analysis. The NED students undertake projects in which they learn the physics of radiation behavior while becoming familiar with one of the four public-domain radiation transport codes available in the lab. Students typically choose to apply their simulation work to research in radiation therapy. One example is the use of a coupled neutron-photon simulation code to assist in the radiation treatment planning for patients undergoing boron neutron capture therapy at the MIT Research Reactor. Image data taken for each patient are ported to WCBICL where they are input into the simulation; transport calculations are carried out and results are sent electronically back to the New England Medical Center where the data are coupled with the patient's X-ray CT image for review by medical personnel.

J. DAVID LITSTER
Division of Toxicology

The Division of Toxicology is an academic unit of the Whitaker College of Health Sciences and Technology. Its major educational activity is the operation of a graduate degree program leading to S.M./Ph.D. degrees in toxicology. Teaching as well as research programs emphasize mechanisms through which chemical and physical agents in the environment induce toxicity and pathogenesis.

The objective of the programs of the Division is to train scientists who will be professionally qualified to make research contributions to improve understanding of the impacts of hazardous chemicals and other environmental agents on human health, and to educate future generations of scientists with similar interests and qualifications. Special emphasis is placed on development and application of *in vivo* and *in vitro* experimental models and approaches designed ultimately to elucidate, in cellular and molecular terms, mechanisms through which such agents induce their adverse effects. Strong emphasis is placed on the development, validation and application of methodology for detection and characterization of adverse effects that will improve assessment of hazards to humans resulting from environmental exposures. Utilizing biochemical, chemical and biological approaches, the training of pre- and post-doctoral trainees is concerned with: characterization of effects of toxic, carcinogenic and mutagenic chemicals at intact animal, tissue, cellular and molecular levels; development of methods for the detection and quantification of such effects in humans, experimental animals, and other experimental systems; studies of metabolic activation, macromolecular binding and genetic effects; and elucidation of modes of action at cellular and molecular levels.

**FACULTY**

Faculty members whose primary academic affiliations are in the Division include Professors Peter C. Dedon, John M. Essigmann, Steven R. Tannenbaum, David B. Schauer, William G. Thilly, Gerald N. Wogan, and Helmut Zarbl. Dr. James G. Fox, director of the Division of Comparative Medicine also is a Professor in the Division of Toxicology. Professors Essigmann, Tannenbaum and Wogan hold joint appointments in the Department of Chemistry, and Professor Thilly in the Department of Civil Engineering. Professor Thilly also serves as Director of the Center for Environmental Health Sciences in Whitaker College of Health Sciences and Technology. Faculty members of the Division are drawn from a wide range of disciplines, and as noted above, some hold joint appointments in the Departments of Chemistry, Civil Engineering and in the Division of Comparative Medicine. Toxicology faculty members also form the nucleus of the MIT Center for Environmental Health Sciences.

**EDUCATIONAL PROGRAM**

The Division offers a graduate degree program leading to PhD or SM degrees in Toxicology. The curriculum is designed to provide rigorous training in basic sciences, with particular emphasis on graduate subjects in biochemistry, molecular biology, genetics as well as toxicology. Graduates of the doctoral program follow career paths in academic, industrial or governmental organizations requiring applications of modern methods of chemical, molecular biological and genetic analysis to research related to evaluation of risks associated with chemical exposures. The scope of both educational and research programs encompasses subject matter appropriate to chemical, biotechnology, pharmaceutical, and food industries, as well as to governmental regulatory and research agencies.

Students admitted into the degree program pursue a series of required and elective subjects that ordinarily require three semesters to complete. Following successful completion of a written comprehensive examination, usually administered in the fourth term of study, students must submit and defend a thesis proposal not later than three semesters later. Presentation and defense of the thesis proposal to a thesis
committee constitutes the oral portion of the doctoral examination. Thesis committees are comprised of three to five faculty members from the Division of Toxicology as well as other departments of MIT, Harvard or other institutions as required by the nature of the doctoral thesis research.

AFFIRMATIVE ACTION

Specific efforts to recruit members of underrepresented minority groups are made at several levels. In the context of general recruiting efforts, all notices and other documents clearly state the MIT and program commitment to recruitment of minority candidates. Additional recruiting efforts include internships, faculty visits, conferences, mailings and informal networking by current minority trainees.

An important and most fruitful avenue of contact with prospective minority students has been through the MIT Minority Summer Science Research Program. This program was initiated in 1986 as an institutional effort to address the issue of underrepresentation of African Americans, Hispanics, and Native Americans in mathematics and the physical and biological sciences in the United States. The Summer Science Program is designed to provide opportunities for talented minority sophomores and juniors to spend a summer on the MIT campus working in an active research program under the guidance of faculty, postdoctoral fellows, and graduate students. The Toxicology faculty have consistently been active participants in the Summer Program since its inception; each summer four to six Toxicology faculty sponsor interns. Indeed, this has proven to be an effective recruitment path, as four of our currently enrolled minority doctoral candidates were Summer Program interns before joining the Division. The Summer Science Program interns receive advice and information about graduate study directly from their Faculty Sponsors and laboratory supervisors. In addition, the 1993 Summer Program held an information-gathering Forum entitled "Graduate Study at MIT". This Forum provided an opportunity for all interns to meet with representatives of MIT math and science departments in order to learn more about the various graduate programs offered at the Institute. An information packet was sent by the Toxicology Graduate Student Office to several of the interns unable to attend the Forum. As an incentive to attract more minority applicants, MIT waives the fee normally required to apply for graduate study.

Toxicology faculty are also involved in minority recruitment activities outside of MIT. For example, a Division faculty member met with and distributed Toxicology literature to more than 50 students at the November 1991 National Institute for General Medical Sciences Minority Programs Symposium in Washington, D.C. In Fall, 1990, the Division was represented by one of our Senior Research Scientists at the Minority Access to Research Careers (MARC) Conference in Nashville, Tennessee. At approximately annual intervals, at least one faculty member personally visits campuses of colleges that enroll large numbers of minority students in order to meet with prospective applicants and to develop contacts with faculty members of science departments. Visits have been paid to Cayey College, the science school of the University of Puerto Rico as well as the campuses of several Historically Black Colleges and Universities (e.g., Morehouse, Spelman, Clark Atlanta University, Georgia Tech) in the US over the past several years.

Six minority students are currently enrolled as doctoral candidates in the Division. LaCreis Kidd and Deirdre Lawrence both received their undergraduate training in Biology at Spelman College in Atlanta. Donald Brunson attended Morgan State (Baltimore, MD) as a Chemistry major. Dawn Hilliard studied Chemistry at Fisk University, Arkansas. Esequiel Barrera earned his bachelor's degree in Biology at University of California, Irvine. Paula Lee was in the Department of Civil and Environmental Engineering at MIT as an undergraduate before joining the Division of Toxicology. In addition, one minority postdoctoral trainee, Dr. Teresa de Rojas, has been a member of the Division and supported by the Training Grant during the current grant period. Three of the predoctoral candidates (Brunson, Kidd and Lawrence) have passed the doctoral examinations and are engaged in thesis research projects. Brunson is nearing completion of his thesis research and Kidd and Lawrence expect to complete theirs within twelve to eighteen months. Dr. de Rojas is completing her postdoctoral training, which has been very productive, as indicated by publications emanating from her research.
The Division has been represented by one or more currently enrolled minority students at several recruitment conferences as well as through informal networking. For example, Toxicology students have represented our graduate program at several schools and meetings, including the annual Minority Access to Research Careers (MARC) and Ford Fellows meetings. Indeed, one student (Lawrence) who received two years of support through the Ford Foundation program is currently serving on the planning committee of that program. One African American student (Brunson) has spoken to groups of minority science students at Lincoln University, Morgan State University, and at the Beta Kappa Chi National Honor Society Annual Meeting over a period of five years. These African American students also participated in a three-day recruiting visit organized by the MIT Dean's Office to colleges in the Atlanta area in October, 1992. Further, a Hispanic graduate student in the Division (Barerra) has been an enthusiastic MIT/Toxicology representative at the annual meeting of the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) whose mission is to encourage its students to obtain graduate degrees in the sciences in order to pursue advanced research and teaching careers. The student attended the January, 1993 annual meeting of SACNAS, and both the student and his advisor attended the 1994 meeting in Chicago. The Winter 1993 issue of SACNAS News included a quarter-page announcement describing the Division of Toxicology Ph.D. program.

These efforts to recruit members of underrepresented minorities into the Toxicology program are being conducted in coordination with institutional programs with similar objectives within MIT. Current efforts as well as those proposed for the future have been developed with the support of and in consultation with Isaac M. Colbert, Associate Dean and Margaret D. Tyler, Assistant Dean of the Graduate School of MIT for minority student affairs. Further coordination of the Toxicology activities with other institutional initiatives is fostered by the continuing participation of the Program Director, G. N. Wogan, as a member of the MIT Equal Opportunities Committee, whose responsibilities include development of institutional initiatives relating to minority recruiting at all levels.

RESPONSIBLE CONDUCT OF RESEARCH

Over the past several years, MIT has placed particular emphasis on the need to address the issue of ethical research conduct. In May, 1991, the President and Provost appointed a Committee on Academic Responsibility. The Committee was charged to: (a) review the current situation with respect to the community values in connection with the conduct of academic research; (b) review existing policies and procedures in connection with the conduct of research in view of the values held by the MIT community; (c) compare existing MIT policies and procedures with guidelines and regulations of federal and private research sponsors; and (d) suggest innovative education and mentoring programs directed towards raising the consciousness of our community concerning issues associated with the conduct of research and also propose mentoring programs related to faculty career development. The report of the Committee, entitled "Fostering Academic Integrity" was published on April 15, 1992 and distributed to the MIT community. This document is among several that have been used in training activities related to responsible conduct of research within the Division of Toxicology.

The faculty organized a half-day convocation in September, 1993, to foster discussion of ethical conduct in science to all of those involved in research within the Division, including graduate students, undergraduates, technical staff, and postdoctoral associates. Attendance by predoctoral candidates and postdoctoral associates was mandatory, and other staff personnel were encouraged to participate. Dr. Stephanie Bird, Special Assistant to the Associate Provost at MIT, who has had extensive experience in establishing ethics training programs for other units at MIT provided invaluable assistance in the organization, content and conduct of the Colloquium. Several faculty, graduate students, postdoctoral fellows, and other researchers were designated to be group presenters and/or facilitators, and Dr. Bird conducted a brief training session for this group prior to the Colloquium. Prior to the Colloquium, all those invited to attend received a copy of the MIT brochure, Fostering Academic Integrity, together with written scenarios of ethical dilemmas that were scheduled to be discussed at the program.
Seventy-one members of the Division attended. The format consisted of two panel presentations of scenarios in a plenary session, each of which was followed by discussion. Participants then divided into small discussion groups for further discussion of specific issues raised by individuals, following which a second plenary session was held, and summary presentations were made by group facilitators for further discussion. The Colloquium was clearly thought-provoking, and elicited extensive suggestions of related topics for future programs. A majority of the attendees rated the Colloquium as interesting and useful, and substantive suggestions were made for modifications such as greater emphasis on ethical dilemmas specifically confronting graduate students and postdoctoral associates. Among these were issues relating to: authorship; collaborations; confidentiality; professional standards; ethics guidelines at MIT; research pressure; falsification of data; and laboratory management. These suggestions will be taken into account as we plan for future similar large-group programs. In the meantime, Toxicology faculty have agreed to incorporate discussions about ethical research behavior into laboratory group meetings, courses, and other occasions that provide a forum for frank discussion of this important topic.

HONORS AND AWARDS

The following honors and awards were accorded to students of the Division during the current academic year.

Ms. Aoy Tomita, a student in Professor Thilly's research group, received an Ida Green Fellowship.

Mr. Zhenghuan Chen, a student with Professor Essigmann, received the Whitaker Health Sciences Fund Fellowship.

Ms. LaCreis Kidd and Mr. Donald Brunson, both in Professor Tannenbaum's research group, received fellowships from the Minorities Access to Research Careers (MARC) program of the National Institutes of Health and Ms. Deirdre Lawrence has been supported by Minority supplement from NIH.

Ms. Deirdre Lawrence, a member of Professor Wogan's group, has been supported through the Minority Supplement Program of NIH.

Mr. Esequiel Barrera, a student in Professor Essigmann's group, received support through a National Research Service Award for Minority Students.

GERALD N. WOGAN
MOST IMPORTANT PROGRESS

BASIC STUDIES IN GENETICS AND TOXICOLOGY

One. Professor Helmut Zarbl and Dr. Rita Cha published their finding that the oncomutation found in most breast cancers of rats induced by the alkylating agent methylnitrosourea was not induced by the treatment but existed prior to treatment. This finding overturns the widely believed, but erroneous, interpretation that the specific H-ras mutation observed was caused by the chemical.

They further deduced that this pre-existing oncomutation occurred during puberty within three cell divisions coincidental with first estrus resulting in small colonies of these mutant cells in mature rats. This observed burst of oncomutation during organ growth in puberty has led to the hypothesis that such events explain the appearance of breast and testicular cancer in young adults.

Two. Professor Helmut Zarbl's laboratory extended these studies of chemically induced breast cancer by showing that the H-ras promoter region of rat breast cells is normally in a configuration resistant to enzyme digestion but that this configuration is altered to a digestible form in all breast cells soon after treatment with the carcinogen, methylnitrosourea. This finding has opened up a new area of study and understanding as to how chemical exposure may effect expression of mutant oncogenes.

Three. Dr. Jia Chen studied the kinds and positions of mutations induced in human cells by a common environmental carcinogen as a function of dose rate. They found at concentrations equal to those reported for human lungs that the kinds and positions of mutations were quite different from those induced by the much higher concentrations used in animal or microbial studies upon which risk assessment calculations are based. Since these "mutational spectra" reflect the mechanisms of mutagenesis these data emphasize the inherent inaccuracy of extrapolation from high dose rate studies to the low dose rates of human experience.

Four. Professor Steven Tannenbaum's laboratory has now perfected means to measure environmental chemical reaction products with the cellular proteins, histones, most intimately associated with genetic material. Since histones are present in cells of all organs this advance will permit studies of exposure in several modes blood and urine, samples surgical discard specimens, or autopsy.

Five. A promising advance toward measuring environmental chemical reaction products attached to the genetic material, DNA, has been reported by Professor Gerald Wogan’s group. This improvement replaces the use of radioactive phosphate with radioactive sulfur to label reacted DNA products.

Six. Working with students Peter Southam and Aoy Tomita, Professor William Thilly has developed a lifetime model relating the rates and numbers somatic mutations to the age specific death rate from cancer in humans. Professor Stephan Morgenthaler, chair of the department of mathematics, ETH in Switzerland, has joined in a formal collaboration to test and extend the model to analyze cohorts based on birth year.

COMMUNITY STUDIES OF WATER AND AIR POLLUTION

Seven. Professors Harold Hemond and Dennis McLaughlin with Drs. John Durant, Ilhan Olmez and Arthur Lafleur have now combined chemical analyses of sediment cores in the Aberjona River with hydrologic models of water intake of Woburn's municipal wells G and H. They calculate that a discharge of many tons of chromate, arsenite and other toxic metals would have severely contaminated the well water leading to tap water concentrations as high as 4 \( \mu M \) chromate and 1 \( \mu M \) arsenite. The period of use of these wells is contemporaneous with the appearance and disappearance of the infamous Woburn leukemia cluster. The interdisciplinary effort has provided a clear, plausible and testable hypothesis relating this particular exposure to the elevated leukemia rates in the effected community.

Eight. In a collaboration with Professor Glen Cass (Caltech) Drs. Charles Crespi, Bruce Penman (Genest Corp., Woburn) John Durant and Art Lafleur have measured the human cell mutagenicity of air particulate chemicals from Washington DC and Los Angeles. They find that while the combustion related polycyclic aromatic hydrocarbons contribute a significant (25%) fraction of this activity, slightly more polar compounds, possibly carbonyl derivatives of the polycyclic aromatic hydrocarbons (PAH) are responsible for most of the activity of small air borne particulates. Such
carbonyl compounds are known to form from PAH in the presence of oxygen and sunlight but heretofore the specific chemical(s) responsible for human cell mutagenicity have not been identified.

COLLABORATIONS AND OTHER ACTIVITIES

The Center for Environmental Health Sciences is involved in a set of collaborations aimed at complementing the interests and abilities of MIT faculty and facilities. With the University of Rochester Medical school to study the amount of certain chemicals and the mutational spectra in human lung epithelial cells from which human lung tumors arise. With the California Institute of Technology to combine the Caltech experience and expertise in air sampling and source attribution with our own ability in combustion engineering, toxicology and analytical chemistry. With multiple investigators interested in studies of the amounts and kinds of mutations in tissues from which tumors arise: Radium Hospital (Oslo), Brigham and Women's Hospital (Boston), University of Pennsylvania Medical School (Philadelphia). With the New Jersey Institute of Technology and Caltech to study regional differences in source and distribution of air-borne toxicants. With the Eidgenossische Technische Hochschule (Lausanne) to develop and test mathematical models relating mutation of cells in organs to organ specific cancer death rates. With the Harvard School of Public Health to include faculty studying the molecular mechanisms of DNA repair. With Gentest Corporation (Woburn) to develop human cell lines which accurately mimic the metabolism of environmental chemicals found in normal human organs and tissues.

With seventeen universities across the country we have explained the research needs and goals of university interdisciplinary research groups aiming at understanding the health effects of exposure to local hazardous waste deposits. This legislative educational effort made faculty presentations to members of Congress or their appropriate aides both in the home districts and in Washington DC. 155 members of the House and 36 members of the Senate were reached in March through May 1994. The effort was coordinated by our CEHS.

EXTERNAL SUPPORT

Center for Environmental Health Sciences faced competitive review of two major programs and its center grant in the past year. The Center Grant has been funded to 1999 (NIEHS), our program studying the role of nitric oxide as an internal toxicant to 1999 (NCI) and our program studying mutation induced in human lungs by air pollutants to 1997 (NIEHS). We have just submitted a competitive renewal proposal for the Superfund Basic Research Program (NIEHS). Three additional program grants face competitive renewal this coming year. (NIEHS, DOE).

Center for Environmental Health Sciences
Director
WILLIAM G. THILLY (Toxicology and Civil Engineering)
Associate Directors
Klaus Biemann (Chemistry)
Harold Hemond (Civil and Environmental Engineering)
Adel Sarofim (Chemical Engineering)
Steven Tannenbaum (Toxicology and Chemistry)
Helmut Zarbl (Toxicology)
INTRODUCTION
The Harvard-MIT Division of Health Sciences and Technology (HST), established in 1970, provides a means of collaboration between Harvard and MIT that makes available educational and research opportunities that could not be exploited as effectively by either institution through its own independent efforts. Its MD curriculum produces physicians who have a deep and quantitative understanding of the underlying science of medicine and biomedical research. The PhD programs combine rigorous scientific or engineering graduate training with an in-depth exposure to the biomedical sciences and clinical medicine. Both programs seek to prepare students for leadership roles in medicine and biomedical science.

The HST Division facilitates and administers programs in research which are concerned with important biological and health problems which can be addressed in a multidisciplinary manner through the collaborative efforts of biomedical scientists, physical scientists, engineers, and clinicians from the two participating institutions.

ADMINISTRATION
The HST Division is administered by two Co-directors who report to J. David Litster, Professor of Physics and Vice President and Dean for Research at MIT, and S. James Adelstein, Professor of Medical Biophysics and Executive Dean for Academic Programs at Harvard Medical School (HMS). Roger G. Mark, Grover Hermann Professor of Health Sciences and Technology is the MIT Co-director, and Dr. Michael Rosenblatt, Robert Ebert Professor of Molecular Medicine is the Harvard Co-director. Dr. Joseph Bonventre, Associate Professor of Medicine at HMS, serves as Associate Director of HST and Director of Student Affairs for HST-MD students.

ACADEMIC PROGRAMS
A total of 261 graduate students were registered in HST degree programs during the academic year. One hundred eighty were MD candidates of whom 91 were simultaneously pursuing PhD degrees. Ninety-three students were registered in HST doctoral programs: 73 in the Medical Engineering and Medical Physics (MEMP) track, 15 in the Speech and Hearing Sciences (SHS) track, and 5 the Radiological Sciences Joint Program which is sponsored jointly by HST and the Nuclear Engineering Department.

HST offers approximately 70 courses in the biomedical sciences and biomedical engineering, a number of which have been developed jointly with other MIT departments. More than 150 faculty members at MIT and at Harvard Medical School contribute significantly to the academic programs of HST. The Division has a "core" faculty numbering nine individuals (including the directors).

A major new training program for clinical investigators was launched this year under the direction of Dr. Robert Rubin, an HST Affiliated Faculty member. The program is centered in the MIT Clinical Research Center, and is run jointly with a similar module at the Beth Israel Hospital. Under sponsorship from Pfizer, Inc., the training program provides two-year fellowships for physicians who have completed specialty training, and who wish to prepare for careers in clinical investigation. In steady state there will be 10 fellows at HST who will engage in both didactic instruction and in clinical research projects under the mentorship of faculty members from MIT and HMS. The Clinical Investigator Training Program is the largest of its kind in the country, and will meet a major national need for highly skilled clinical investigators.

The MD degree was awarded by HMS to 33 HST students this year, of whom 7 received honors; 2 others received separate awards. Ten students received MEMP doctoral degrees from MIT (8) or Harvard (2).

Ms. Naomi Chesler, a MEMP student working in the laboratory of Mechanical Engineering Professor Roger Kamm, won the Ayukawa Prize this year; and Mr. John Kuo, an MD/PhD candidate working in the laboratory of Biology Professor Hazel Sive, won the Ayukawa Travel Prize.

The external HST Advisory Committee visited the Division for two days in March, 1994. It reviewed the academic programs, administrative and faculty structure, and proposed new initiatives of the Division. The Committee's report to the Provost of MIT and Dean of HMS underlines the excellence of the Division's
educational programs, and contains a number of important and constructive assessments and recommendations for the future.

RESEARCH PROGRAMS
An objective of HST from its inception has been to foster development of interdisciplinary, inter-institutional collaborative research between the faculties of MIT and Harvard. The research of the HST core faculty and research staff covers a wide spectrum of biomedical areas including: auditory physiology (including therapeutics); pathophysiology, epidemiology, and therapy of atherosclerosis (including diagnostic instrumentation); biological response of tissue such as cartilage to mechanical, chemical and electrical factors; fundamental biology of translation-level control of gene expression; structure-function analysis of interleukin I-B; cryobiology; hyperthermia for cancer therapy; biomedical instrumentation; tissue engineering; systems physiology and modeling; physiological signal processing; vascular biology and pathophysiology; and fundamental pathophysiology of bone. Their research links include a number of HMS teaching hospitals (MGH, BWH, BIH, NEDH) and the HMS quadrangle. HST also administers a number of research programs for affiliated faculty. The total projected fiscal year '94 research volume is $5.6M. The research activities of the Clinical Research Center, organizationally part of HST, are reported separately.

FACULTY AND STAFF
Martha L. Gray, J. W. Kieckhefer Associate Professor of Electrical and Medical Engineering, was chosen as the 1994 recipient of the prestigious Edgerton award. She was also promoted to tenure at MIT.

Lee Gehrke, Lawrence J. Henderson Associate Professor of Health Sciences and Technology, was promoted to tenure at HMS.

Elazer Edelman, Hermann von Helmholtz Assistant Professor of Health Sciences and Technology and Assistant Professor of Medicine at HMS, won a Burroughs Wellcome Experimental Therapeutics Scholar Award in a nation-wide competition.

Professor Michael Rosenblatt was named a fellow of the American Association for the Advancement of Science at their 1994 meeting in San Francisco.

Cecil H. Coggins, Associate Professor of Medicine and Clinical Director of the Renal Unit at Massachusetts General Hospital was chosen to receive the Irving M. London Teaching Award, recognizing the excellence of his teaching in HST 110 Renal Pathophysiology.

Dr. Cynthia D. LuBien joined HST as Director of Development on January 1. She was previously Manager of Corporate Relations in MIT's Industrial Liaison Program. She reports jointly to the directors of HST and to the Development Offices of both MIT and HMS. She has made major progress in forging effective mechanisms for cooperative fund-raising, as evidenced by several major new gifts for endowment.

AFFIRMATIVE ACTION
The HST Division endorses the affirmative action plan at MIT, and continues to make every effort for equality in employment, promotion, and education regardless of race, color, sex, religion, national origin, or handicap. We have actively attempted to increase the number of qualified student applicants from minority groups, including making visits to several minority colleges and conferences for minority science students. Minority students serve on the MD Admissions Committee. We are pleased that our new Director of Development, and our most recently tenured MIT faculty member are women, and that our most recently hired senior staff assistant is Afro-American.

ROGER MARK AND MICHAEL ROSENBLATT
The mission of the Technology Licensing Office (TLO) is to facilitate the transfer of technology from M.I.T. (and the Whitehead Institute) to industry, and thereby to benefit the public good through the development and subsequent sale of commercial products. A secondary goal is to generate unrestricted funds to motivate inventors and to support research and education at M.I.T. The TLO staff of 23, with 11 professionals and twelve support personnel, are responsible for identifying marketable technologies, managing the patenting and copyrighting of these technologies, finding licensees to develop the technologies and negotiating licenses.

A total of 84 License and Option agreements were signed, including a dozen new startup companies. In addition, we granted 18 new trademark licenses and 97 end-use software licenses. We have now completed transfer of responsibility for X-Window licenses to an independent outside organization.

Gross Income for the year was $8.7 Million, which included $155K cask-in of equity. Of the gross, $6.5 Million was in royalty income, $1.7 in patent reimbursement income, and $275K in miscellaneous research support. $1.4 Million will be distributed to inventors, $1.4 to departments, and a net of $873K to the General Fund.

We continued an active licensing and technology transfer program for Lincoln Laboratories which now accounts for 20% of our new invention disclosures and a similar fraction of new licenses.

Members of the Technology Licensing Office have been very active at the state and federal level in aiding legislation and other activities to do with economic development, changes in patent law and changes in technology transfer legislation. They have also been active at the committee and board levels with the Association of University Technology Managers, the Licensing Executive Society and the Association of Federal Technology Transfer Executives.
A supernova is defined by the American Heritage Dictionary as "a rare celestial phenomenon involving the explosion of most of the material in a star, resulting in an extremely bright, short-lived object that emits vast amounts of energy." This will serve as a description of the Center for Cognitive Science as well. After an active and productive fifteen year history which has, among other things, seen the publication of well over 25 books and 200 hundred articles, the Center comes to an end.

The Center was founded in 1979 with a two and a half million dollar grant from the Sloan Foundation. During its lifetime the Center constructed and maintained a much needed human subjects laboratory capability for the then Department of Psychology. It provided support for dozens of young scholars just starting out on their careers, many of whom have since gone on to become leaders in their fields. It provided a home for visiting scholars, a seedbed for the Lexicon Project, and, perhaps most importantly, laid the groundwork for the creation of the cognitive component of the Department of Brain and Cognitive Sciences.

The Center, throughout its history, was governed by a Working Group composed of faculty from Electrical Engineering and Computer Science, Linguistics and Philosophy, the AI Laboratory, the Research Laboratory of Electronics and the Department of Psychology and, subsequently, the Department of Brain and Cognitive Sciences.

For the record the members of the Working Group were Professors Jon Allen, Sylvain Bromberger (co-director), Robert Berwick, Ned Block, Susan Carey, Morris Halle, Richard Larson, David Pesetsky, Jim Higginbotham, Alec Marantz, Dan Osherson, Molly Potter, Ken Stevens, Richard Held, Steven Pinker (co-director), Jay Keyser, Shimon Ullman and Ken Wexler. Over the years these scholars operated in an atmosphere of collegiality and respect which might well serve as a model for other Centers. These scholars brought the Center into being and, quite fittingly, have voted to bring it to a quiet end, to be replaced by a Seminar for Cognitive Science that will bring important speakers to the MIT campus three to four times a year.

Samuel Jay Keyser, Co-director
MIT has an extraordinarily strong and broad effort in materials science and engineering involving approximately 110 faculty members in eleven departments in the schools of science and engineering. Several centers and laboratories at MIT have been established to facilitate industrial participation in such research. There is great opportunity in this environment to solve problems that address the needs of society more effectively by encouraging collaboration. Thus, the Center for Materials Science and Engineering (CMSE) has a special mission: to foster collaborative interdisciplinary research and education in the fundamental science of materials and in the engineering of materials for specific applications. CMSE not only promotes collaboration among MIT faculty trained in different disciplines, but also between MIT researchers and the researchers of other universities, industry, and government and nonprofit laboratories.

Collaborative research is encouraged through several mechanisms: interdisciplinary research groups (IRGs), shared experimental facilities (SEFs), infrastructure enhancement, and outreach programs. The IRGs, described below, are composed of MIT faculty who, with their students and postdoctoral associates, wish to investigate fundamental scientific questions and pathways to reach significant technological goals that can only be properly explored in a collaborative, multidisciplinary mode. These problems are too large in scope to be addressed by individual faculty members and their students. Collaboration is essential for materials-related science and engineering, even for individual investigators, because such research requires very sophisticated equipment and infrastructure. CMSE provides a mechanism for the purchase and supervision of such equipment in its SEFs. The equipment is made available to the members of the IRGs, individual MIT investigators, and researchers from other university, industrial, government, and nonprofit laboratories. In these facilities, students, postdoctoral associates, and industrial researchers working on different topics intermingle and transfer expertise and technology across traditional disciplinary boundaries. CMSE also supervises the operation, maintenance, and improvement of the Vannevar Bush building, thus providing the infrastructure necessary for first class materials research. Researchers from four departments are intermixed in the building, facilitating interdisciplinary cooperation.

The center has been supported by the National Science Foundation (NSF) under its Materials Research Laboratory (MRL) program. This program will be replaced by a new Materials Research Science and Engineering Center (MRSEC) program on September 1, 1994, for which CMSE has submitted a five-year proposal. CMSE staff and faculty have spent considerable time over the past year reviewing the present program and preparing the proposal and a follow-up panel presentation at the NSF. Proposals for new IRGs were stimulated for the proposal by notifying members of the MIT materials community early in 1993. After an initial screening of twelve group proposals, eight were subjected to detailed review by the Internal Advisory Committee (IAC) and by other knowledgeable MIT faculty, and each of the eight were also reviewed by at least two referees from outside MIT. The internal and external referees were asked to rate the proposal with regard to five criteria: the past research performance of the senior investigators, the likelihood of important scientific results from the proposed research, the coherence of the IRG, the interdisciplinary quality of the IRG, and the potential technological impact of the research. Five of the groups were rated excellent and were included in the proposal. Each IRG was also reviewed by a new CMSE Science and Engineering External Advisory Board (SEEAB).

CMSE also provides seed funds. While preference is given to young faculty, CMSE uses these funds to support research that has the potential of redefining the direction of an existing IRG or leading to the creation of a completely new IRG. Among the members of the proposed IRGs are six faculty members who began with seed funding in the last five years. Seed funding provides CMSE with the flexibility necessary to initiate high-risk research. Past seed funding has led to the founding of several start-up companies that provide more than 100 jobs, demonstrating both the importance of seed funding and the value of basic research in creating wealth.
INTERDISCIPLINARY RESEARCH GROUPS

IRG-I: Microphotonics Materials and Structures
The purpose of this program is to explore the fundamental nature, synthesis, and properties of Photonic Band Gap (PBG) materials and to exploit these properties for the design and fabrication of novel structures and devices for the creation and control of electromagnetic radiation. These materials are ideally a composite of a periodic array of macroscopic dielectric scatterers in a homogeneous dielectric matrix. A PBG material affects the properties of traveling electromagnetic waves in much the same way that a crystal of atoms affects the properties of electron waves. Consequently, photons in PBG materials can have band structures, gaps, localized defect modes, and surface modes. By allowing the trapping, localization, and channeling of light with very low loss, these new materials have the potential of completely revolutionizing the basic elements of photonic and optoelectronic integrated circuits. The bending radius of a conventional planar waveguide is limited to 1 cm by scattering losses; this geometry is incompatible with integrated photon distribution on a chip. A PBG material will allow a 10 mm radius bend, and provide a gateway to microphotonics. The research addresses a broad range of fundamental issues in novel synthesis pathways for inhomogeneous microstructures, new photonic phenomena, and components for well-defined systems applications. The group has already fabricated and begun to characterize a one dimensional PBG waveguide with a bandgap centered at 5 mm, composed of a set of colinear air holes in Si.

Participating faculty and departmental affiliations: Professors H. A. Haus, E. P. Ippen, L. A. Kolodziejski, and L. R. Reif (Electrical Engineering and Computer Science); E. R. Brown (Lincoln Laboratory); L. C. Kimerling (Materials Science and Engineering); and J. D. Joannopoulos (Physics).

IRG-II: Molecular and Supermolecular Engineering of Polymeric Systems with Novel Electronic and Optical Properties
The objective of this group is to develop the chemistry and molecular-level processing needed to control and manipulate the molecular and supermolecular organizations of macromolecular systems with novel electrical and optical properties. The development and utilization of combined molecular/supermolecular engineering schemes will make it possible to design and fabricate complex, multiphase or multicomponent systems with controllable molecular architectures and well-defined morphological arrangements. Thus, it will be possible to create multi-component systems in which each component serves a well-defined function and is molecularly positioned to achieve a specific and tunable electrical, optical, or chemical response. The juxtaposition of different components, such as semiconductor nanocrystallites and conjugated polymers, may result in new and useful electronic and optical behavior. Applications of interest include highly anisotropic electrically conducting films, photonic devices, periodic dielectrics, and thin film electroluminescent and energy storage devices. For example, the group has recently fabricated green and blue light emitting diodes using conducting polymers and polymer/semiconductor-nanocrystal heterostructures.

Participating faculty and departmental affiliations: Professors R. E. Cohen (Chemical Engineering); M. Bawendi, R. R. Schrock, and R. J. Silbey (Chemistry); and M. F. Rubner and E. L. Thomas (Materials Science and Engineering).

IRG-III: Phase Behavior in the Presence of Quenched Randomness and Frustration
Cooperative behavior in the presence of frozen-in randomness, i.e. ordering in the presence of quenched disorder, permeates all of materials science. Whereas phase changes in perfect systems are well-understood, the disorder challenges our ability to understand even qualitative effects and to make precise predictions and measurements. Cooperative phenomena in the presence of quenched randomness may also underlie fundamental mechanisms of life sciences and have applications to information sciences in, for example, neural networks or coding-decoding processes. Much of what is understood about the consequences of quenched randomness is based on piecemeal results rather than exhaustive, consistent experimental and theoretical studies. This group plans to effect such a study. They will probe this one fundamental problem, ordering under quenched disorder, from different directions while requiring interconnected and mutually consistent interpretations. Model systems proposed for study include gels with random distributions of positive and negative charges and random antiferromagnets. The gels have recently received attention for their potential application in many different arenas.
Participating faculty and departmental affiliations: Professors C. W. Garland (Chemistry); and A. N Berker, R. J. Birgeneau, M. Kardar, J. D. Litster, and T. Tanaka (Physics).

IRG IV. Structure, Chemistry, and Transport Properties of Intercrystalline Interfaces
The properties of polycrystalline materials are largely dominated by the properties of their surfaces and grain boundaries. Oxides possess the greatest range of interfacial properties of scientific and technological interest, owing to a richness of chemical and electronic phenomena not found in most other materials. However, due to greater complexity, these materials are at the same time the least understood. The goal of this IRG is to develop a unified and comprehensive understanding of the role of atomic level structure, chemistry, and local electronic structure in determining the physical properties of crystal interfaces. Towards this goal, a collaborative effort in the growth, detailed characterization, and computational modeling of grain boundaries in model oxides is proposed. The two materials chosen for study, TiO2 and ZnO, have technological applications that depend on the behavior of their interfaces: TiO2 is the primary opacifying component in paint and ZnO is the material of which varistors are made. The successful growth of single grain boundaries in these oxides and the use of electron microscopy to study their chemistry on the nm length scale has enabled this group to approach this problem in a way never before possible.

Participating faculty and research staff and departmental affiliations: Professors R. W. Balluffi, Y.-M. Chiang, H. L. Tuller, J. B. Vander Sande, and B. J. Wuensch (Materials Science and Engineering); and Dr. A. J. Garratt-Reed (CMSE).

RGV. Transition Metal Oxides
The discovery of high-temperature superconductivity in copper oxides has renewed interest in the more general problem of transition metal oxides, where strong correlations between the electrons are known to play a key role. For example, the parent compound La2CuO4 is an antiferromagnetic insulator, contrary to the prediction of band theory, and becomes metallic and superconducting when doped. Many believe that the superconductivity is a new manifestation of the correlated behavior of the electrons in the two-dimensional copper oxide layers. It follows that the physics of strong correlations must be better understood before the superconductivity can be explained. The goal of this group is, therefore, to study the properties of transition metal oxides in order to guide the development of a theory of correlated systems and ultimately explain the mechanism of high-Tc superconductivity. The group's strategy for reaching its goal has three parts: detailed studies of the magnetic, electronic, and optical properties of single crystals, development of a theoretical framework for the analysis of the data, and a search for new compounds. The growth of large single crystals for neutron scattering experiments is a unique strength of this effort. These crystals made possible the discovery of low energy optical excitations in undoped copper oxides like La2CuO4.

Participating faculty and departmental affiliations: Professors R. J. Birgeneau, M. A. Kastner, and P. A. Lee (Physics); and H.-C. zur Loye (Chemistry).

MATERIALS EDUCATION, HUMAN RESOURCE DEVELOPMENT, AND OUTREACH
CMSE's programs contribute to the education of both undergraduate and graduate students in a variety of ways. A joint program with the Materials Processing Center (MPC) combines NSF Research Experiences for Undergraduates (REU) with industrial funds to bring students from all across the nation to MIT in the summer to become involved in materials research. The SEFs are also important in undergraduate education. Courses, such as those in X-ray scattering and microfabrication, teach the students to use processing and characterization facilities and to carry out research projects using the equipment. A new course, Materials Synthesis and Processing, taught by the Department of Materials Science and Engineering and initiated with partial NSF support, uses the SEFs extensively. In addition, short courses are taught using the facilities during the Independent Activities Period. At the graduate level, CMSE plays a critical role in the education of almost all the students at MIT who do materials-related research. In addition to those involved in the IRGs, the shared facilities are used by graduate students from eleven academic departments.
COLLABORATION WITH INDUSTRY AND OTHER SECTORS
CMSE collaborates with other laboratories and centers at MIT that carry out materials-related research and engineering with direct involvement of industry and other sectors. Collaborations are especially active with two of these, the MPC and the Microsystems Technology Laboratories (MTL). CMSE collaborates with these centers through joint sponsorship of research, joint publications, and joint symposia. MPC and CMSE have a joint Industrial Advisory Board which reviews the effectiveness of collaboration between CMSE and industry and recommends ways of enhancing it. The board also advises CMSE about opportunities for modifying its research programs to address society's needs. MPC has begun to aggressively develop industrial participation in the application of the results of IRG research through working groups and workshops. CMSE will present results of interest to the electronics industry at the MTL Microelectronics Research Review. The cost of equipment for CMSE facilities is shared by MTL and MPC whenever appropriate, and CMSE facilities are modified in coordination with these organizations to assure that the overall spectrum of facilities offered by MIT is as broad as possible without unnecessary redundancy.

The SEFs are a critical feature of CMSE's collaborations with non-MIT personnel. The facilities are made available to any researcher from a nonprofit institution and to industrial researchers when equivalent facilities are not available commercially. In the past 18 months CMSE facilities have been utilized by 40 companies and 27 outside academic institutions. A facilities manager will soon be hired to assure that the SEFs meet the needs of this wide variety of users. The current CMSE/IBM X-ray participating research team (PRT) at the National Synchrotron Light Source (NSLS) at Brookhaven, the future CMSE/IBM PRT at the Argonne Advanced Photon Source (APS), and the Brookhaven/CMSE/AT&T/Exxon neutron scattering PRT at the Brookhaven High Flux Beam Reactor are very special facilities constructed and operated with direct industrial and government laboratory collaboration. These PRTs and the neutron diffraction PRT at the National Institute of Standards and Technology (NIST) provide time for use of facilities to users from all sectors. Finally, several of the IRGs propose direct research collaboration with industry and other sectors. This is important for exchange of knowledge and the education of graduate students, for it provides them with direct experience of industrial research.

AFFIRMATIVE ACTION
No permanent members were added to the CMSE research or administrative staff. Three male postdoctoral associates were appointed this year: Mikhail Noginov ended his term on July 31, 1993; Chao-Yang Zhang, Asian, was appointed for the period January through May, 1994; and Alec Sandy was appointed on May 1, 1994. Of the three visiting scientists appointed this year, two were women, Rosangela Itri and Irina Mnuskin.

Of the 11 students participating in the CMSE Undergraduate Research Opportunities Program, funded by the National Science Foundation Research Experiences for Undergraduates (REU), five students were men and six students were women, one of whom was African-American, Sharon S. John, and one Hispanic, Maribelle Rodriguez. This June, CMSE began a collaboration with the MPC in the sponsoring of a joint REU ten-week summer internship program. Seven interns were selected from 118 applications submitted by undergraduates from both MIT and other universities from around the country. Three of these scholars are women: Marcie Black, MIT; Andrea Franke, Carnegie Mellon University; and Brianna Smith, Dillard University, who is also an African-American.

As part of its outreach program, CMSE participates in the cooperative employment in its shared experimental facilities of students from Northeastern University and Wentworth Institute. Of the five students employed this year, one student from Wentworth was an Hispanic male, Nestor Hernandes, and another was an African-American male, Harold Cadet. Nestor worked in the Microfabrication Facility for one term and Harold for one year.

CMSE also participates in the Cambridge Teenwork program that fosters after school and summer office employment of Cambridge high school students. An African-American young man, Ashley Lissaint, worked for one half of the school year, and an African-American woman, Danyell Garner, worked for the second half of the school year.
CMSE continued our very successful science and engineering summer day camp for seventh- and eighth-grade students from a local public school who are members of underrepresented minority groups. The students were supervised by volunteer faculty and staff, as well as four MIT African-American students, three men, Nikki Caruthers, Matthew Phillips, Sambou Makalou, and one woman, Dawne David.

In our recent NSF MRSEC proposal, we proposed to initiate the CMSE graduate minority research assistant (RA) program. The objective of the CMSE RA program will be to fill the need for support for minority students in their last two years of graduate study. Each year we will make available one such assistantship lasting two years. Seed grant funding was also requested to provide support to underrepresented minority faculty working in the field of materials science and engineering.

MARC A. KASTNER
INTRODUCTION
The Clinical Research Center (CRC) was established in 1964, with grant support from the National Institutes of Health (NIH), to provide a facility in which Massachusetts Institute of Technology (MIT) investigators and their collaborators could apply the Institute’s expertise in basic biochemical and biophysical mechanisms to the analysis of normal and pathologic processes in humans. MIT’s CRC was the first federally supported clinical research center located in a university and not within a hospital. It was anticipated that in spite of its university venue, a large enough number of qualified physicians from MIT’s faculty and staff would utilize the CRC to study normal volunteers, or patients with chronic diseases, to warrant its existence.

Scientists and physicians authorized to carry out research protocols using the CRC’s facilities include: professors; research scientists who work exclusively at MIT; and those with primary appointments in local medical institutions whose research interests overlap extensively with those of MIT investigators. Research protocols must be approved by the MIT Committee on the Use of Humans as Experimental Subjects (COUHES) and the CRC Advisory Committee before they can be implemented. The CRC Advisory Committee, chaired by Harvard-MIT Division of Health Sciences and Technology (HST) Visiting Professor John Burke, consists of 10 voting members plus six non-voting members of the CRC’s program staff. The Committee reports to the principal investigator, Roger Mark, Professor and Co-Director of HST, and meets bi-monthly to evaluate protocols for their scientific quality, experimental design, statistical analysis and potential risk to human subjects. The Committee also sets general policies and reviews the operations of the CRC.

ADMINISTRATION
The CRC presently has a dual administrative locus within MIT. As a research unit, the CRC reports through HST to the Vice President and Dean for Research, Professor David Litster. However, as a patient-care unit, the CRC is a part of the MIT Medical Department and reports to Dr. Arnold Weinberg, the Director of the Medical Department. Members of the CRC participate in the Medical Department activities; i.e., Quality Assurance, Pharmacy and Therapeutics, Medical Records, and Safety Committees.

In coordination with the MIT Medical Department, a major administrative effort was the preparation for the Joint Commission on the Accreditation of Healthcare Organizations (JCAHO) accreditation review in October, 1993. The Medical Department and the CRC were accredited with commendation on November 16, 1993.

During the past year the MIT Clinical Research Center (CRC) received from the MIT Technology Licensing Office $421,000 as its share of MIT royalties from patents based on studies done entirely or in part at the CRC. The Advisory Committee in concert with the MIT Administration chose to use these funds to provide for eight "seed money" grants, the purpose of which was to draw new investigators and new projects into the CRC. Formal applications were solicited and reviewed; eight were ultimately funded. These projects and investigators were:


2. In Vivo Magnetic Resonance Spectroscopy (MRS) Studies of Choline Uptake and Metabolism in the Brain of Alzheimer’s Disease. Dr. Bruce Cohen, Associate Professor of Psychiatry, Harvard Medical School; Associate General Director/Research, McLean Hospital; Visiting Scientist, MIT Clinical Research Center.

3. Fuel Oxidation and Substrate Cycling in the Lipodystrophy Syndrome. Professor William Dietz, Research Scientist, MIT/Harvard Division of Health Sciences and Technology; Associate Professor, Pediatrics, Tufts University School of Medicine; Assistant Director, MIT CRC.

4. Evaluation of 11C-labeled D-Fenfluramine as a PET Ligand for Studying Pre-Synaptic 5-HT Receptor Kinetics in Human Subjects. Dr. Alan Fischman, Director, Massachusetts General Hospital, Division of Nuclear Medicine.

5. Development of a Diagnostic Test for Alzheimer’s Disease. Dr. John Growdon, Professor of Neurology, Harvard Medical School; Program Director, Massachusetts Alzheimer’s Disease Research Center, NIA; Lecturer, MIT, Department of Brain and Cognitive Sciences (B&CS).
6. *Ethnicity and Risk Factors for Hip Fracture.* Professor Wilson Hayes, Vice Chairman, Research, Beth Israel Hospital, Department of Orthopaedic Surgery.

7. *The Use of Timolol, a Drug which Acts on the Sympathetic System to Increase Accommodation to Blur.* Professor Richard Held, MIT, Department of B&CS

8. *Effects of Physiological Doses of Melatonin on Human Sleep Behavior.* Dr. Donald Schomer, Associate Professor of Neurology, Harvard Medical Center; Visiting Lecturer, MIT, Department of B&CS

These grants have already generated a number of active projects. We are not certain whether comparable funds will be available in the future; however we hope to continue this program to the extent possible.

**CORE LABORATORY/MASS SPECTROMETER FACILITY**

The Core Laboratory focuses its activity on laboratory assays that directly support CRC research. The most important and complex effort is undertaken in the Mass Spectrometer Facility, where stable isotope tracer analyses are undertaken. The major purpose of this shared instrument facility is to service the analytical needs of CRC investigators who use stable nuclide tracers in human metabolic studies. Principal areas of investigation concern the regulation of energy substrate metabolism in health and disease, and the regulation of whole body amino acid metabolism, with particular reference to the nutritional requirements for indispensable and conditionally indispensable amino acids.

Research at the MIT CRC in both of these areas have made important contributions to the further development of national and international dietary standards and the establishment of sound food and nutrition policies and programs.

Studies have continued on the role of dietary arginine as a precursor of the signal transducer nitric oxide, and the novel doubly labelled water (\(^{2}H_{2}^{18}O\)) method is being used to define the energy requirements of adolescent and elderly subjects, and factors which affect these needs. These various investigations offer new basic knowledge about the physiology of human energy substrate and amino acid metabolism and, additionally, make practical contributions to problems in human nutrition.

The Core Laboratory received a new Beckman High Performance Liquid Chromatography System (HPLC) with funds awarded by the N.I.H., freeing up for other uses the old system which had been performing amino acid analyses. The new system is more sensitive, capable of detecting up to 42 physiologic amino acids. A PC now monitors and controls the autoinjector, pumps, and detector. Previously laborious tasks of integration, data collection and reporting are now compiled and performed on the PC. An analog-digital interface also permits the PC to monitor, control and record the output of an additional HPLC. These features will be very important in the development of new assays.

A HPLC assay for the determination of plasma tryptophan was developed. This new assay offers several advantages over the fluorometric assay it replaced, including lower costs, increased sensitivity and decreased technician time. A new assay for catecholamines has also been developed, and several investigators are interested in developing HPLC assays for cytidine and bromide.

**COMPUTER FACILITY**

The computer facility expanded the computer hardware to include PC's located in the nursing, dietary, core lab and administrative areas. The PC's were connected to the DECSystem which is the main CRC computer system and to MITnet. Proper ergonomic workstation furniture was also installed at the site of each PC.

Many researchers were trained in the use of the SAS statistical software and the new windows technology. Throughout the year researchers were able to transfer data from a wide variety of computers and software packages into SAS on the DECSystem. Formal training was offered in statistics and SAS programming.

The development of the new Research Information Systems software has experienced some delays in implementation. The CRC's PDP-11 computer is still being used for the Center's day-to-day operation.

**EDUCATION**

The CRC has continued to provide postdoctoral training for physicians who are participating in fellowship programs at MIT. These physicians have utilized the CRC's facilities to initiate research protocols and to participate in ongoing projects supervised by senior investigators and faculty. The CRC is embarking upon a new Clinical Investigator Training Program, starting in July, 1994, directed by Dr. Robert Rubin, Associate Professor of Medicine, Harvard
Medical School and Affiliated Faculty Member of HST. This program, funded by a grant to MIT from Pfizer, Inc., will underwrite the stipends of three postdoctoral fellow for the first year starting in July, 1994, and up to 10 fellows to June 1997. Each fellow will work in close concert with a CRC investigator and also take one or more courses related to clinical investigation. During 1992-93 seven post-doctoral fellows and three graduate students participated in research projects at the CRC through the Department of B&CS. At the undergraduate level, nine Undergraduate Research Opportunities Program (UROP) students participated in clinical research projects with physician preceptors and faculty supervisors.

**AFFIRMATIVE ACTION**
The hiring of women and minorities continues to be a high priority at the CRC; our primary problem in meeting affirmative action objectives has been attracting qualified minority candidates. The traditional means of advertising and posting positions in local colleges, universities, medical institutions, and minority organizations have not resulted in a significant response from qualified minorities.

This past year no research staff positions became available. One secretarial position did become available, and a woman was hired. Four Visiting Scientists were appointed, two female (one a minority) and two males. The center will continue its efforts to increase the pool of qualified minority applicants as positions become available.

**RESEARCH ACTIVITIES**
During the past year, most of the research activities of the CRC have continued to be associated with three clinical areas, and to involve three groups of scientists, each led by a senior professor. These areas are: Nutrition/Metabolism (Vernon R. Young, professor, MIT School of Science) - an area in which the CRC constitutes the major locus of MIT's activity, and one that is a traditional component of clinical research centers; Neurochemistry/Neuropsychopharmacology (Richard J. Wurtman, Professor of Brain and Cognitive Sciences and Program Director, MIT CRC) - studies on the effects of drugs, foods and hormones on brain composition and behavior; studies on biologic rhythms in sleep and hormone secretion; studies on a set of diseases characterized by affective and appetitive symptoms (i.e., depression, premenstrual syndrome, smoking withdrawal, carbohydrate craving, obesity), which seem to relate to brain serotonin; and Behavioral Neuroscience (Suzanne Corkin, Professor of Brain of Brain and Cognitive Sciences) - focusing on the effects of diseases on cognitive and related brain functions and on genetic and other mechanisms causing neurodegenerative disorders (i.e., Alzheimer's disease). Groups collaborate on multidisciplinary projects, e.g., obesity; depression; Alzheimer's disease. Moreover, numerous CRC research collaborators involve both an MIT professor and investigators at an outside hospital or research laboratory.

This year the CRC patient census totaled 263 inpatient days and 1,956 outpatient visits.

**RESEARCH HIGHLIGHTS**
- Dr. William H. Dietz and his associates continued their work on adolescence and obesity: Adolescence represents a major risk period for the development of obesity in girls. Furthermore, adolescent onset obesity is associated with a variety of complications in adulthood, including cardiovascular disease, diabetes, and breast cancer. Although the prevalence of obesity in girls in the United States is increasing rapidly, the effects of altered energy expenditure on the development of obesity has not been carefully examined. For the last five years, Dr. Dietz and his colleague, Visiting Scientist, Dr. Linda Bandini, have been conducting a study of 197 young adolescent girls drawn from the Cambridge and MIT communities. The initial goal of the study was to determine whether parental obesity affected total daily energy expenditure, resting metabolic rate, the amount of energy spent on activity, or maximal oxygen consumption during a treadmill exercise. No effect of parental obesity on any of these measures has been observed. These results suggest that parental obesity does not predispose for obesity by reducing energy expenditure prior to the development of obesity. The focus of the study has now shifted to a prospective study that will examine whether alterations in total daily energy expenditure, resting metabolic rate, the amount of energy spent on activity, or maximal oxygen consumption predispose to the development of adolescent obesity. If reduced energy expenditure of a subcohort of girls as they progress through adolescence will help determine the magnitude of the decline in energy expenditure, and provide quantitative recommendations for the amount of activity necessary to prevent adolescent obesity.

- Dr. Suzanne Corkin and her associates focused on two areas: (1) Vision in Alzheimer's Disease - Deficits in basic visual functions are prevalent in AD and reflect lesions of peristriate cortex and other visual areas. Dr. Corkin and her associate investigators examined the relation between basic vision and cognition in 60 subjects with AD. Vision tests assessed color discrimination, stereocuity, contrast sensitivity, and backward masking. For cognitive tests
of object identification (e.g., incomplete pictures), subserved by temporal cortex, at least 25% (up to 57%) of variance was explained by performance on any vision test. For tests of spatial cognition (e.g., map reading, mental rotation), subserved by posterior parietal cortex, less than 25% (as low as 7%) of variance was explained by performance on any vision test. The results indicate that degeneration of peristriate and other visual areas in AD impacts more deleteriously upon cognitive functions associated with the ventral than the dorsal visual processing pathway. 2) Functional Brain Imaging - Dr. Corkin and her associate investigators are among the first to use high-speed functional magnetic resonance imaging (fMRI) methods to address issues in cognitive neuroscience and in neural plasticity. They have embarked upon two projects: (a) The Neural Substrates of Cognition in Aging and Alzheimer’s Disease (AD), and (b) Changes in Human Somatosensory Processing Following Deafferentation. The goals of the first project are to obtain clues about the changes in MRI signal intensity with specific cognitive changes in aging and AD, to document individual differences in those changes, and to identify neurophysiological markers that may signal very early AD. The goal of the second project is to evaluate the hypothesis that phantom limb perceptions result from the reorganization of central neural structures. They will examine whether submodalities of somatosensory perception in humans are altered differentially following deafferentation, and whether these changes are confined to specific somatosensory processing channels. The fMRI studies will allow them to assess directly changes in neural activity following deafferentation, and to correlate these changes with the percepts of the phantom limb and the percept of phantom pain.

The fMRI studies will be performed in collaboration with the functional brain mapping group at the MGH-NMR Center in Charlestown. All subjects will be admitted to the MIT CRC, where we will develop cognitive and sensory tasks that are feasible within the scanner environment, will pretest subjects on the tasks to be used in the scanner, and will maintain databases to compare test performance in the scanner with test performance under standard testing conditions. These studies will provide exciting new opportunities for MIT students and faculty in cognitive neuroscience and systems neuroscience, using the excellent multidisciplinary resource in Charlestown.

Dr. Paul Spiers, CRC Visiting Scientist, and his associates reported the following: - In the fall of 1993, the first phase of the CDP-Choline protocol was completed. This study administered a well-tolerated dose of CDP-Choline to normal elderly individuals to determine if this compound could lead to improved memory functioning in the face of normal aging. The results indicated significant promise for CDP-Choline, particularly for elderly subjects in the lower range of memory performance, those with age consistent memory impairment. These findings are consistent with ongoing observations that the availability of dietary choline o the brain for neurotransmitter synthesis may become significantly reduced with normal aging and suggests that memory decline may be reversible, thus improving elder productivity and reducing health related costs of treating forgetfulness or its consequences.

This research was made possible as a result of the unique combination of resources available at the CRC, almost all of which were utilized by this project. Nursing staff, CRC physicians, and the CRC’s statistician all contributed to this project and the CRC’s outpatient facilities, core laboratory, computer center, and dietary service were actively involved. The CRC’s pool of volunteer subjects also contributed to more rapid subject recruitment and allowed for the completion of this project in a timely fashion.

B&CS Research Scientist Dr. Judith Wurtman’s research was focused on the effects of two drugs, dexfenfluramine and fluoxetine on weight gain among women participating in a smoking cessation program. The drugs were chosen because they have been shown in previous studies to minimize weight gain among individuals going through nicotine withdrawal; this study was designed to compare the two drugs and to describe, in addition to their effects on weight gain, their effects on smoking withdrawal associated side effects and mood changes over the three months of smoking cessation. The study was completed in December of 1993 and the data are being analyzed. Preliminary results indicate that both drugs minimized weight gain during the first four weeks following nicotine withdrawal and that dexfenfluramine, but not fluoxetine, maintained its effect on depressing weight gain for the following two months. In addition, more women completed the study who were treated either with placebo or dexfenfluramine than fluoxetine.

The results of this study may be extremely important in assisting individuals giving up smoking (with the well known benefits that smoking cessation provides). Almost all individuals gain weight as they go through a smoking cessation program and some continue to gain weight for month thereafter. The anticipated weight gain has been known to cause individuals to hesitate to give up smoking and cause others to return to smoking in an attempt to lose the weight they gained previously. Obviously, any intervention that can decrease weight gain associated with smoking withdrawal is advantageous in promoting smoking cessation with its attendant health and medical cost benefits. Moreover, preventing
or minimizing weight gain among those already at risk for obesity is extremely important as one does not want to replace the health hazards of smoking with those associated with obesity such as diabetes or hypertension.

- Dr. Richard J. Wurtman and his associates demonstrated that: 1) Exposure to bright light (300, 1500, 3000 lux) diminishes normal nocturnal serum melatonin levels in a dose-dependent manner. Performance on vigilance, reaction time, and other tasks deteriorates significantly throughout the night, consistently with known circadian variations in these parameters, but independently of ambient light intensity and circulating melatonin levels. 2) Compared with placebo, ingestion of melatonin (10, 20, 40 or 80 mg) at 1145 h causes a significant decrease in oral temperature, number of correct responses on auditory vigilance, response latency in reaction time, and self report feelings of vigor. Melatonin also increases self-reported feelings of fatigue, confusion, and sleepiness. No differences in these effects were found among the four melatonin doses tested, suggesting that all of the doses were sufficient to saturate melatonin receptors within the body. Melatonin may have direct acute physiologic hypnotic effects, independent of previously reported indirect effects on circadian rhythms. 3) Late morning administration of melatonin, in doses which increase circulating serum melatonin levels to within (0.1 and 0.3 mg), and outside of (1.0 and 10 mg), the normal nocturnal range, significantly increase sleep duration as well as self-reported sleepiness and fatigue, relative to placebo. All doses also significantly decreased sleep onset latency, oral temperature, and number of correct responses on the Wilkinson Auditory Vigilance Test. These data indicate that a daytime increase in circulating serum melatonin, to levels approaching but within, the normal nocturnal physiologic range, results in highly potent hypnotic effects - relative to placebo. Similar results were observed after increasing the daytime serum melatonin levels to well beyond the normal nocturnal physiologic range. These results support those found with larger doses and further support the hypothesis that melatonin may exert direct hypnotic effects, independent of circadian effects. It is hypothesized that the normal nocturnal increase in serum melatonin levels may constitute a signal initiating normal sleep onset.

- Dr. Vernon R. Young and his associates continued studies on human amino acid metabolism and requirements. Dietary proteins are required in an amount sufficient to meet the physiologic needs for the indispensable (essential) and conditionally indispensable amino acids and also for nitrogen which is used for the synthesis of dispensable (non-essential) amino acids and other physiologically important nitrogen-containing compounds. Hence, the maintenance of an appropriate content of body protein and normal functioning of cells depends upon the adequacy and balance of intake of these nutrients; pathological conditions can profoundly alter these relationships and the requirements of specific amino acids. During the past year they have continued to re-evaluate the physiological requirements of the indispensable amino acids. They continue to conclude, through a series of complex 24 hour stable (non-radioactive) isotope tracer studies on the kinetics of leucine and phenylalanine metabolism in healthy adult subjects, that the current international indispensable amino acid requirement values are far too low. Further, their research for this past year has been concerned particularly with the conditionally indispensable amino acid, arginine, and it has helped to identify the physiologic mechanisms responsible for maintaining human body arginine balance. They have clarified the metabolic basis for the conditional indispensability of arginine, which they have now shown is due to its variable rate of degradation, without a compensating change in the rate of de novo arginine synthesis. This research has improved significantly their definition of the physiology of amino acid metabolism and the concepts and approaches required to establish the quantitative requirements for amino acids in human beings. It has also provided a more secure metabolic background for evaluating the potential significance of dietary arginine supplementation at relatively high levels, which, for example has been proposed for a variety of possible therapeutic purposes, such as in major trauma or in the potential treatment of hypertension.

RICHARD J. WURTMAN
INTRODUCTION
Decision sciences is an interdisciplinary topic emerging in importance in many industries in both service and manufacturing sectors. It is a field that helps to guide individuals and public and private organizations in making informed decisions, often concerning the effective use of scarce financial, human, and technical resources. The explosive development of new sources of information and the continuing emergence of ready access to faster and more powerful computers have created both enormous potential and considerable need for more informed decision making. The Decision Sciences Program (DSP) aims to exploit these opportunities by developing innovative educational and research programs and by working closely with industry.

AFFILIATED FACULTY
Professor Thomas L. Magnanti, George Eastman Professor of Management Science, served as the Program's Director, and Professor Richard C. Larson, as its Associate Director. The Center has approximately 20 affiliated faculty and senior research staff drawn from all five schools at MIT.

ACADEMIC PROGRAM
A primary goal of the new program is to support graduate education in the decision sciences at MIT, enriching ongoing programs like those at the Operations Research Center, and creating new opportunities in areas like statistics and decision processes.

The disciplinary base of the decision sciences ranges from behavioral decision theory and psychology to applied mathematics, economics, operations research, optimal control, and statistics, all topics that help inform individuals and organizations in making decisions. Recognizing the interdisciplinary nature of the field, the DSP draws upon existing resources and expertise in other centers and programs, including the Operations Research Center, the Laboratory for Information and Decision Systems, the Center for Transportation Studies, the Leaders for Manufacturing Program, the Center for Educational Computing Initiatives, and the Center for Computational Research in Economics and Management Science.

This past year, as part of a larger effort on manufacturing education, three of the Decision Sciences affiliated faculty were part of a faculty team that received a TRP (technology reinvestment program) grant for undergraduate education; as part of the larger overall effort, the Decisions Sciences faculty will be developing multimedia approaches to teaching probability and statistics, with a particular emphasis on manufacturing applications. This effort was coordinated with the Leaders for Manufacturing Program and the Center for Engineering Computing Initiatives.

This past spring, DSP admitted its second PhD student.

RESEARCH
The Decision Sciences Program aims to promote cross disciplinary research in both underlying theory and applications. Two such efforts are underway.

Air Transportation Management
The DSP signed a Memorandum of Understanding with the Center for Advanced Aviation System Development (CAASD) of the MITRE Corporation for a multi-year collaborative effort to conduct research in the general domain of air transportation. As part of this umbrella agreement, MITRE will support summer interns from the Center and will exchange visitors with MIT. One student served as an intern this past summer. DSP and MITRE have already received a $1 million grant from the FAA to develop models and solution methods for air traffic flow management. Professor Amedeo R. Odoni will
be the principle investigator for this effort. Air transportation management, and especially air traffic
control and air transportation safety, raise important planning and policy issues that can draw upon the
considerable experience and expertise of the MIT faculty. DSP is coordinating its efforts on this topic
with MIT's Flight Transportation Laboratory.

Transactional Data Laboratory
Frequently, when individuals or organizations make transactions, they generate considerable data.
Examples are bar-code laser scanned data from supermarkets, customer interaction data from Automatic
Teller Machines (ATM's), materials movement and position data from assembly lines, stocks and options
trading data, point of sale data from retailers, and satellite data giving estimates of vehicle locations.
The DSP aims to develop a Transactional Data Laboratory that interprets and discovers ways to better
utilize such data. Equipped with a sample of new transactional data acquisition technologies, the
laboratory will resemble traditional laboratories at MIT. In addition to computers, the laboratory will
include examples of data acquisition technologies that are creating enormous (gigabyte) data explosions.
This past year several faculty at MIT, working with faculty from other universities and with a few
individuals from industry, have begun to develop a research program and research proposal for the
Transactional Data Laboratory.

The Decision Sciences Program functions as a virtual program, with very modest infrastructure (space,
staff). Its intent is to be a new type of organizational entity at MIT that helps to stimulate and
coordinate initiatives that cut across traditional Institute departments, centers, and laboratories. It also
aims to develop new initiatives that might not normally fit into existing organizational entities. The
TRP educational grant, the support of statistics at the Institute, the MITRE collaboration and FAA
research grant, and the Transactional Data Laboratory are examples of the types of activities that DSP
seeks to develop as part of this overall mission.

THOMAS L. MAGNANTI
Director
Introduction
The Division of Comparative Medicine (DCM) provides animal husbandry and clinical care for all research animals on the MIT campus. From its inception in 1974, the Division has evolved into a comprehensive laboratory animal program that provides a full range of veterinary and surgical support. Additionally, the Division has a National Institutes of Health (NIH)-funded training program for veterinarians specializing in laboratory animal/comparative medicine and conducts externally funded research focusing on diseases in laboratory animals. Total personnel in the Division now comprises 65 individuals.

Facility Management and Animal Care
The average daily census of laboratory animals increased approximately 22 percent during FY94. This is a continuation of a five year trend during which the animal census has increased 120 percent. Mice remain the primary species used by MIT investigators and represent more than 95 percent of the animal population. More than half of the 25 animal technicians have earned accreditation from the American Association of Laboratory Animal Science as a result of ongoing training and passing an examination. The Center for Cancer Research in conjunction with DCM has received funding of $1.2 million from the National Cancer Institute (NCI) for a major renovation of the E17/18 animal facilities. Renovations will commence early in FY 95. Building 68, the new biology building, has a 32,000 gsf animal resource. Animals will be moved into this space in the months ahead. The MIT animal resource program received AAALAC accreditation for the next three years based on a site visit last summer.

Research Activities
The DCM Diagnostic and Investigative Laboratory is in its 19th year of funding from NIH. This grant enables the Division to pursue research projects associated with diseases of laboratory animals and development of relevant in vivo models. Other NIH-funded grants support in vivo study of nitrite carcinogenesis, the study of Helicobacter pylori and its relation to gastric cancer, and an examination of the intestinal metabolism of B-carotene. NCI funded a two year study of Helicobacter hepaticus which has been linked to liver cancer in mice. Private pharmaceutical firms have provided funding for the derivation of specific-pathogen-free ferrets and for Helicobacter research. The Division’s NIH postdoctoral training grant was been renewed for a second five year period starting 7/1/93. There are currently six postdoctoral trainees, two of whom are enrolled in graduate programs in the Division of Toxicology. Demand for veterinarians with training in comparative medicine remains particularly strong in both academia and industry.

DCM faculty and staff published two chapters, 17 papers and 22 abstracts in FY94 and presented numerous research papers at national and international meetings.

Academic Activities
The Division has recruited a number of new staff members. Dr. David Schauer has a joint appointment as an Assistant Professor in the Division of Toxicology and the Division of Comparative Medicine. Dr. Charmaine Foltz, an ACLAM boarded diplomate joined the Division as a clinical veterinarian, and Dr. Xiantang Li, an ACVP boarded diplomate, joined the Division as a comparative pathologist. DCM faculty and staff taught the graduate course Toxicology 218.

Committee on Animal Care Activities
Didactic training sessions were conducted throughout the year by DCM staff in conjunction with the Committee on Animal Care to train Institute personnel on topics pertaining to the care and use of laboratory animals. The committee completed an instructional video for investigators using animals. The video is available to MIT researchers both at the Division and in the Schering-Plough Library. Nearly 200 institutions have requested a copy of the video.

James G. Fox, DVM
Professor and Director
INTRODUCTION

The Energy Laboratory and its associated Center for Energy and Environmental Policy Research (CEEPR) are multi-disciplinary organizations bringing together sectors of the MIT community with research interests related to energy supply, policy, technology, and utilization and associated environmental, economic, geographical, and societal impacts. Professor Jefferson Tester is the Director of the Energy Laboratory, supported by Associate Directors Drs. Elisabeth Drake and William Peters, and Administrative Officer Susan Guralnik. The CEEPR is directed by Professor Richard Schmalensee, with Dr. A. Denny Ellerman, Executive Director, and Joan E. Bubluski, Administrative Assistant.

For more than 20 years, the Energy Laboratory has sustained a unique organizational structure to develop and implement strong single- and multi-disciplinary energy-related work at MIT. It provides a variety of research opportunities for students at all levels - from the Undergraduate Research Opportunities Program to postdoctoral studies. Our research programs in FY94 involved about 50 undergraduates and 120 graduate students, along with about 50 associated faculty members from eleven Academic Departments representing all five of MIT's Schools.

With a fairly small and stable staff, the Energy Laboratory has limited opportunities for recruitment. However, we are attentive to the goals of affirmative action and committed to increasing the representation of minorities and women on our staff. One of the two Associate Directors and the Administrative Officer are women. The senior management team of the Laboratory thus consists of two women and two men.

SELECTED CURRENT ACTIVITIES

Last September, the Energy Laboratory organized a program for the Energy Sector of the World Economic Forum meeting held at MIT during September 1993. Professors Tester and Henry Jacoby co-chaired the sectorial activities. Sessions included: Energy Supply Technologies for the 21st Century (moderated by Professor Emeritus David White); Privatization, Deregulation, and Competition (moderated by Professor Schmalensee); Incentive Regulation vs. Command-and-Control in Environmental Management (moderated by Professor Schmalensee); and Future Energy Markets: Resources, Technology, OPEC and Prices (moderated by Professor Nazli Choucri). A number of other Energy Laboratory research participants were involved in these sessions and in several smaller interactive sessions.

Many of the Laboratory's projects involve quantitative and cross-disciplinary study of complex energy and environmental systems. Collaboration with the Center for Environmental Health Sciences (CEHS - directed by Professor William Thilly) seeks to determine how combustion emissions and effluents from treatment of hazardous wastes may lead to adverse human health impacts. The Sloan Automotive Laboratory, directed by Professor John Heywood and managed by Dr. Victor Wong, with sponsorship that includes three consortia (Engine Research, Engine/Fuels Interactions, Engine Lubrication), is continuing promising research to improve fuel economy and utilization within the engine and reduce adverse emissions. This work is now being coupled in a synergistic program with research led by Professor Gregory McRae on the modeling of impacts of vehicle emissions on air quality.

Professor Adel Sarofim is leading an EPA Exploratory Research Center on sources, atmospheric transport and transformation, monitoring, and control of airborne organic compounds, staffed with colleagues from MIT, the California Institute of Technology, and the New Jersey Institute of Technology. MIT scientists participating in the Center's research projects include Professors János Beér, Heywood, Simone Hochgreb, Jack Howard, McRae and Sarofim, and Dr. Peters. In addition to the research, the Center hosted a Summer Symposium entitled Scientific Basis for Ozone Control: Strategies for the Northeast, which was chaired by Professor McRae. In another multi-university initiative, several Energy Laboratory researchers are involved with the Emission Reduction Research Center (ERRC), which is headquartered at the New Jersey Institute of Technology. Dr. Maria Flytzani-Stephanopoulos is the associate director, coordinating the MIT research programs. Funded by a group of pharmaceutical companies, the National Science Foundation, and the State of New Jersey, the ERRC seeks new methodologies for preventing pollutant formation and for reducing or eliminating industrial pollutant emissions.
Dr. Malcolm Weiss and Professor Kent Hansen are directing a multi-project program on environmental restoration and waste management within the Department of Energy's nuclear weapons complex. Management projects include a system dynamics study of the Hanford waste tanks (Professor Hansen), an examination of the public advisory boards at individual DOE sites (Dr. Weiss), and four related technology projects involving Professors Jeffrey Lang, Lawrence Lidsky, and Richard Lyon and Drs. Chathan Cooke and Richard Lanza. In a parallel program, management, sociological, and technological issues affecting the safety of existing nuclear power plants worldwide are being studied in the MIT International Program for Enhanced Nuclear Power Plant Safety, directed by Professor Hansen; the program involves Professor John Carroll and the participants in the technology projects of the DOE program.

The Electric Utility Program (EUP), directed by Mr. Stephen Conners, is jointly sponsored by more than thirty electric utility companies, equipment manufacturers, and fuel suppliers worldwide, and the U.S. Department of Energy. EUP facilitates the development of collaboratively funded electric industry related research projects by bringing together MIT faculty and researchers with EUP members through an annual series of workshops and meetings. Ongoing research involves such MIT groups as the Combustion Research Facility (Professors Beér and Sarofim), the Laboratory for Electromagnetic and Electronic Systems (LEES), the Parsons Laboratory, the Department of Nuclear Engineering, and the Building Technology Program (Profs. Leon Glicksman, James Axley, and Leslie Norford). In addition to these predominantly department-based research groups are multi-disciplinary labs such as the Center for Environmental Health Sciences and the Analysis Group for Regional Electricity Alternatives (AGREA). This last group, led by Mr. Conners, uses multi-attribute tradeoff analysis to compare alternative strategies that the electric utility sector might use to meet future electricity needs economically and in an environmentally sound manner. The AGREA group is currently exploring cost-effective Clean Air Act and CO₂ mitigation strategies for New England, as well as the impacts of biomass generation in Western Europe. The New England project is guided by a diverse group of stakeholders encompassing representatives of the utilities, regulatory agencies, and public interest groups. EUP research activities encompass all aspects of the electric industry from basic combustion chemistry and efficient electricity use, to energy efficient building design, to the development of environmental mitigation and long-range integrated planning and pollution prevention strategies.

The Combustion Research Facility, which has produced a number of significant innovations in clean coal combustion technology over the years under the leadership of Professor Beér, is being closed this summer due to a long-standing problem of underfunding, which we have been unable to reverse. Nevertheless, a strong combustion research program continues to exist within the Energy Laboratory, and a planning effort is being started to look at the future challenges in combustion research and their implications for new programs.

Several programs are underway in the area of Advanced Energy and Manufacturing Technologies. A major collaborative program between MIT and the Idaho National Engineering Laboratory seeks new engineering understanding to improve efficiency and materials conservation in energy-intensive processes. This program, involving faculty from several MIT departments, is directed by Professor David Hardt and managed by Dr. Drake.

The Energy Laboratory is in the second year of a multi-year grant proposal from the DOE Office of Energy Efficiency and Renewable Energy for "Research and Assessment Studies in Support of DOE Programs including analytical capabilities development for research and development and technology transfer related to improved resource conservation and environmental quality." This grant, managed by Dr. Drake, is currently co-funding research projects in the CEEPR (Professors Schmalensee, Julio Rotemberg, and Robert Pindyck), in addition to funding a project on sources of industrial innovation, led by Professor Eric Von Hippel. Another major project, directed by Professors David Marks and Fred Moavenzadeh, is developing planning tools for municipal solid waste managers and industries. This program is an outgrowth of prior initiatives on industrial ecology using simulation models for life cycle analysis of technological alternatives considering environmental, safety, and economic trade-offs.

Under the University Research Initiative of the Department of Defense, a five-year fundamental and applied research program on the use of chemical reactors for supercritical water oxidation of military toxic wastes is being conducted for the Army Research Office. Goals are to develop basic kinetic information on oxidation rates, product distributions and salt precipitation rates; to study corrosion of reactor materials; and to develop reactor models and process flowsheet simulations that will aid in the eventual implementation of the technology. The project team is led by Professor Tester and involves Professors Peter Griffith, Jonathan Harris, Howard, Ronald Latanision, Sarofim, and Kenneth Smith, Dr. Peters, and Mr. Howard Herzog.
In 1992, MIT signed a Visiting Scientist and Collaborative Research Agreement with INTEVEP, the research and development arm of Petroleos de Venezuela. Under this program, MIT researchers are teamed with INTEVEP visitors who participate in synergistic research supported by the program. The program also provides discretionary funding to each research group that hosts an INTEVEP visitor. Funding has been provided for Professors Berker, Nihat Berker, Daniel Blankschtein, Silvia Ceyer, Rick Danheiser, Mehran Kardar, Harri Kytomaa, Latanision, Gilbert Strang, Nafi Toksoz, and Provost Mark Wrighton. MIT directors of the program are Professor White and Dr. Peters.

THE CENTER FOR ENERGY AND ENVIRONMENTAL POLICY RESEARCH

The CEEPR is an activity, jointly sponsored at MIT by the Energy Laboratory, the Department of Economics, and the Alfred P. Sloan School of Management, that funds policy-related research in energy and environmental economics. The Center receives financial support from 23 corporate sponsors and three government agencies who contribute a minimum of $35,000 annually to the Center’s research program.

For the past several years, CEEPR’s principal research focus has been the Joint Program on the Science and Policy of Global Change, conducted in collaboration with MIT's Center for Global Change Science. This program, led by Professors Jacoby and Ronald Prinn, draws on MIT’s traditional strengths in science and economics to conduct the serious interdisciplinary work needed to provide a basis for global climate policy. Over the past year, we have hired the necessary research staff, and work is well under way in developing a framework of interactive climate and economic models by which integrated assessment can be conducted. The Joint Program has just concluded a highly successful meeting in Europe that attracted significant notice and attendance among prospective European sponsors.

The Joint Program has now gained international notice and is actively involved in the process by which global change science and policy are being developed. Chairpersons from the working groups of the Intergovernmental Panel on Climate Change (IPCC) now regularly attend Joint Program meetings, and faculty working with the Joint Program are functioning as reviewers in the international process by which the IPCC's findings are formulated.

As part of CEEPR’s other research, this past year saw the publication of two books that will be the definitive texts in their field for years to come and that collect much of the research CEEPR has sponsored over the past years. These text are Dixit and Pindyck’s Investment Under Uncertainty and Laffont and Tirole's A Theory of Incentives in Procurement and Regulation.

NEW INITIATIVES

The Energy Laboratory External Advisory Board met (in spite of a snowstorm) in March, under the chairmanship of Dr. Samuel Fleming (Bechtel Corporation). Five other senior corporate members also attended. While the group was impressed with the quality and breadth of Energy Laboratory activities, they recognized that academic research funding is becoming tighter, both from the U.S. government and industry. Suggestions for future success include: more focus on flexibility to meet sponsors’ short term needs as part of longer-term graduate research programs; further broadening of our international research activities; a more visible role in clarifying important national energy policy options; clear, concise communication to a wide audience on our successful projects and our positions on strategic issues; and continuing attention to building close and continuing relationships with good sponsors.

Increased international activity is already under way with several initiatives. Under the leadership of the Program in Environmental Engineering Education and Research (PEEER) and the start of a major collaboration between MIT, Eidgenössische Technische Hochschule (ETH - Switzerland), and the University of Tokyo, several Energy Laboratory researchers are developing a collaborative proposal on new planning models for cleaner new technologies. Professor Sarofim has developed a proposal to the New Energy and Industrial Technology Development Organization (NEDO - Japan) to work with the University of Tokyo and Tsinghua University on development of appropriate clean coal technologies for China.

Building on prior internationally visible work relating to technologies for carbon dioxide mitigation through capture and sequestration of fossil-fueled power plant emissions, we prepared a proposal that was accepted by the DOE to further investigate the feasibility and potential environmental impacts of ocean disposal of carbon dioxide. Professor
Tester will lead the project with major participation from Mr. Herzog and Dr. Eric Adams of the Parsons Laboratory. Mr. Herzog is also organizing funding and a proposal to hold the Third International Conference on Carbon Dioxide Removal at MIT in 1996, when it is the North American turn to be host. There are obvious synergies between mitigation technologies and the Joint Program, which we hope to highlight in conjunction with this meeting.

The Energy Laboratory has helped spearhead MIT's efforts to forge new types of industry-university-governmental alliances to improve competitiveness in the U.S. automobile industry. Dean Joel Moses and Professor Tester represented MIT at a 1994 workshop convened by Vice President Gore to launch the U.S. program for a new generation of vehicles. The workshop identified RD&D needs and opportunities for U.S. manufacture of advanced vehicles. Professor Heywood and Dr. Peters subsequently prepared a written prospectus describing new paradigms for MIT-industry collaboration in research and education to improve existing vehicle technology and to help U.S. auto makers sustain profitable, long-term mass production of internationally competitive vehicles. Industry reaction to this proposal has been positive and we are proceeding to develop industrial and government support to begin this program.

A proposal was recently submitted to the DOE Office of Energy Research to conduct A Research Needs Assessment for Future Use of Nanofabricated Materials in Energy Applications. Professors Yet-Ming Chiang and Jackie Ying are the co-investigators for the proposed effort, which represents a new area of research activity for the Energy Laboratory.

The Energy Laboratory is coordinating a national program aimed at developing new technologies for rapid drilling, tunneling, and cavity creation in rock formations. Important applications include drilling for exploitation of deep petroleum, gas, and geothermal energy; mining; and excavation for infrastructure revitalization. Under the leadership of Professor Carl Peterson, a National Institute for Advanced Drilling and Excavation Technologies has been established at MIT to accomplish the aims of the program. MIT contributions include expertise in engineering (Professors Kim Vandiver, Herbert Einstein, Tester, and Michael Cleary) and earth sciences (Professor Toksoz and Dr. Roger Turpening). The major function of the Institute will be to carry out industry-directed RD&D on proposed new technologies. Proposal solicitation and evaluation will be conducted on a national scale with U.S. universities as well as government and industrial laboratories encouraged to participate.

We have continued to seek additional external funding to expand our research in renewable energy. Discussions with the National Renewable Energy Laboratory (NREL) are under way in search of support for several projects related to cleaner, more efficient generation of electricity from biomass. We continue to work for expanded governmental and private sector support for U.S. RD&D on hot dry rock geothermal and hydrothermal energy resources.

CEEPR has just been notified that it was chosen to conduct a two-year evaluation of the costs of the acid rain control requirements of the Clean Air Act Amendments of 1990, with particular emphasis on the innovative emissions trading provisions of the Act. This research, which is sponsored by the National Acidic Precipitation Assessment Program, is part of a broader effort mandated by Congress to obtain independent assessments of the performance of major environmental legislation. This work will be supervised by Professors Schmalensee and Joskow and Dr. Ellerman, whose collective expertise in the economics of emissions trading, electric utilities, and the coal industry is responsible for the grant.

The Joint Program's activities for the next year will focus on the coupling of the component models into the integrated assessment framework and the publication of preliminary results. The major new initiative is the incorporation of an ecological model into the integrated framework which is made possible by the relationship established with the Ecosystems Center of the Marine Biological Laboratory at Woods Hole. Additionally, the Joint Program will be continuing efforts to broaden the influence and base of support with particular emphasis on membership outside the United States and by non-energy industries.

JEFFERSON W. TESTER
Historical Perspective

The Francis Bitter National Magnet Laboratory (FBNML) was established in 1960, with support from the US Air Force, as the first high magnetic field laboratory in the country. It continues to be the primary facility for high magnetic field research in the United States, and operates high magnetic field facilities free of charge to qualified scientists throughout the country. Faculty and staff at the Laboratory design and build both resistive and superconducting magnets, and perform research in condensed matter physics, condensed matter chemistry, materials science and biophysics. There is a large research program in nuclear magnetic resonance (NMR) at the Magnet Laboratory, and the FBNML is initiating a major expansion of magnetic resonance imaging (MRI) activities.

Responsibility to support the Laboratory's operations was assumed by the National Science Foundation (NSF) in 1971. In its 1988 Report, the NSF Panel on Large Magnetic Fields identified many important scientific and technical opportunities in high magnetic field research, and recommended the establishment of a National High Magnetic Field Laboratory (NHMFL). The NSF solicited proposals to establish the NHMFL based upon the FBNML in late 1989, and MIT submitted a proposal in May of 1990. Three proposals were received, the others being from the University of New Mexico and a consortium of Florida State University (FSU) and Los Alamos National Laboratory (LANL).

Despite results of the peer review process stating that the MIT proposal was technically superlative to the other proposals, the National Science Board voted to establish the NHMFL at FSU. Subsequently, the NSF developed a plan which involved keeping the FBNML operational on an interim basis, and provided funding through September of 1995.

High Field Facility

For the past 30 years the primary mission of the FBNML has been the production of intense magnetic fields and their utilization in basic and applied research. Today this same mission remains the focus of the Laboratory, although the details of its execution have evolved in recent years, and will evolve considerably in the near future.

The complement of high field magnets available at the FBNML, which includes two of the world's highest field hybrids operating at 32 and 35 tesla (T) and the largest collection and variety of Bitter magnets of any magnet laboratory, is unsurpassed. The large variety of magnets with different fields and bore sizes housed at the Laboratory allows us to satisfy the needs of a diverse user community for changing complex experimental arrangements. The inventory in the High Field Facility is further enhanced by the availability of 16 nuclear magnetic resonance (NMR) and magnetic resonance imaging (MRI) magnets and spectrometers.

The facility is an irreplaceable resource that is available to the research community. To close a facility with the magnitude of resources available at the FBNML, which are used to the fullest extent on a daily basis by researchers in a variety of disciplines from both universities and the private sector, would be a severe loss to the scientific and technological community. The magnets at the FBNML cannot be transferred to the NHMFL, because they are neither electrically nor hydraulically compatible. This limitation applies to the world record setting hybrid magnets.

It is with this in mind that we intend to seek additional support for the long term operations of the Laboratory. We are planning submission of a major scientific proposal to the NSF in October of 1994 for support effective October, 1995. The proposal will include a request for funds to operate the Bitter/hybrid facility in support of collaborative research efforts in a variety of areas using high magnetic fields. Support will be requested for in-house research, for improvement of the Laboratory's physical facilities, and for Magnet Technology Division initiatives.

Our overall goal is to develop research initiatives directed toward establishing a new laboratory based on key, collaborative programs in cutting-edge science and technology. We envision a multidisciplinary collaboration that utilizes the world-class high field facilities at the FBNML combined with frontier research from MIT, adjacent major universities, and leading industrial research laboratories. We intend that these new initiatives will involve significant numbers of MIT faculty and collaborators, primarily but not exclusively from the Northeast region.

Magnet Technology Division

The Magnet Technology Division of the FBNML has a long and successful history dating from the 1960's, which includes the introduction of many innovations in magnet design such as multifilamentary NMR magnets, hybrid magnets, numerous
improvements in water cooled magnets, and radial cooled magnets. The Division has built five of the seven hybrid magnets in the world, and is considered to be an outstanding group of engineers in the magnet design community.

It is as a result of these efforts that Hybrid III, the 35 tesla (T) hybrid magnet, set a new world record of 35.2 T in a 33 millimeter room temperature bore on May 25, 1994. The water cooled section achieved 23 T using only 7.5 megawatts of power, and the background superconducting magnet was operated at 12.2 T. This record was extended to 38.7 T using ferromagnetic holmium pole pieces at 4.2 degrees kelvin as flux concentrators. The water cooled insert employs a newly available copper-silver alloy conductor developed in Japan.

The 750 megahertz (MHz) NMR magnet is undergoing further testing. A niobium-tin (Nb3Sn) coil with a faulty superconducting joint has been replaced, and all of the Nb3Sn coils have been taken to operating current. The Nb3Sn - niobium-titanium (NbTi) hybrid joints meet requirements. All of the original NbTi coils provided by Kobe Steel Ltd. have had to be replaced as a result of random quenching, which was found to be due to irregular winding and incomplete resin bonding. All except one of the new sections have reached operating conditions, and that section is now being instrumented to locate and repair the source of the quenching.

Currently, the major effort of the Division is design and construction of the 45 T Hybrid V magnet, which is being completed in collaboration with the NHMFL to be installed at FSU. The project is progressing well, and the MIT sections of the magnet are scheduled to be completed by the end of March, 1995. Upon completion, the magnet will provide the highest continuous magnetic field in the world, surpassing only the achievements of the Hybrid III noted above.

Nuclear Magnetic Resonance and Magnetic Resonance Imaging

The FBNML is home to an expanding Center for Magnetic Resonance. This world class facility for high resolution NMR, which was started in 1974, has continuous funding through 1999 from the National Institutes of Health (NIH). The Laboratory is actively pursuing funding to create and operate a Chemistry Research Facility for Very High Field NMR in collaboration with the Harvard Medical School. Plans are to complete work on the 750 MHz NMR magnet designed and built at the FBNML, and to acquire two commercial 750 MHz systems. The first of these instruments has already arrived, and is now being installed.

There are also plans for a major expansion of MRI activities involving the Harvard/MIT Division of Health Sciences and Technology (HST). HST is in the process of recruiting two senior faculty members in the area of functional MRI, and the FBNML Director is working closely with HST faculty toward the successful recruitment of renowned individuals in this field.

Affirmative Action

Due to financial constraints, the Laboratory's efforts to attract new research, technical and support staff have been slowed. The Laboratory currently has no open positions, and there are no plans to conduct any searches during the coming year. For these reasons, the FBNML has postponed establishing affirmative action goals until the future direction of the Laboratory is more certain.
The Haystack Observatory, located in Westford, MA, is an interdisciplinary research center engaged in radio astronomy, geodesy, atmospheric sciences, and radar applications. The radio astronomy program is conducted under the auspices of the Northeast Radio Observatory Corporation (NEROC), a consortium of 12 educational and research institutions in the northeast\(^1\). The Observatory receives financial support from various federal agencies including the NSF, NASA and the USAF through MIT Lincoln Laboratory.

The Observatory instrumentation consists of the following facilities: a 37m-diameter radio telescope enclosed in a radome that is used for astronomical observations at wavelengths from 2.6 mm to 13 cm, as well as for wideband radar measurements at 3 cm; an 18m-diameter radio telescope involved in geodetic measurements of the earth’s plate motions using very long baseline interferometry (VLBI) techniques; a VLBI correlator to process global geodetic experiments and astronomical observations at millimeter-wavelengths; a high-power radar that utilizes two large antennas, 46 m and 67 m in diameter, to study the earth’s upper atmosphere using incoherent backscatter techniques; and an optical observatory to monitor atmospheric airglow emission and measure winds in the upper atmosphere.

The main highlight of the radio astronomy program in the past year has been the operation of the Haystack telescope in its first formal observing season at 3mm-wavelength (85–115 GHz) during January–March 1994, following successful completion of a major upgrade project. A total of 40 observing projects were conducted by members of the astronomical community, including 17 graduate students. The newly-upgraded telescope is presently the most sensitive single dish instrument in the U.S. at 3mm-wavelength, and the combination of its sensitivity and high angular and spectral resolution have allowed many new exciting observations some of which are highlighted below.

The properties of dense molecular cores in our galaxy were studied using C\(_2\)H\(_2\) line emission at 85 GHz, enabling astronomers to resolve the dynamics of clouds and to find consistent evidence for dynamical infall as predicted by the latest star formation theories. Ionic and neutral molecular species in dense regions have been found to be dynamically tied to each other and hence to the magnetic field. All seven hyperfine components of the N\(_2\)H\(^+\) ion at 93.2 GHz were resolved for the first time, allowing stringent constraints on the opacity and column density of this species. This has opened the way to further studies to help determine the ionization level in clouds, and constrain timescales of the ambipolar diffusion process. The high-resolution spectra of N\(_2\)H\(^+\) are of such quality that molecular constants are expected to be derived from these data with more accuracy than from laboratory measurements. Large-scale maps of the Orion Ridge were made in C\(^13\)O at 109 GHz, and were found to overlay very well on the NH\(_3\) structures mapped by the Very Large Array. This work has shown that the filamentary structures seen in the Haystack and VLA maps represent the intrinsic mass distribution rather than chemical or excitation effects.

The compact source Sgr A, in the center of our galaxy, was observed at 86 GHz in a VLBI experiment using Haystack and other telescopes, in order to determine the intrinsic structure of the source. The experiment set a new upper limit on the intrinsic size of Sgr A at one astronomical unit, and obtained a new astrometric position for the source. A number of high resolution maps of the Sun have been made for the first time at 86 GHz, imaging active regions and prominences, and making direct determinations of filament electron densities. In a pilot program to test the capabilities of Haystack for extragalactic observations, the nucleus of the nearby spiral galaxy IC 342 was mapped at 115 GHz, and the structures observed were found to compare well with interferometer maps.

Haystack astronomers have also used other instruments in their scientific research. One recent significant example is the discovery at the Plateau de Bure interferometer of CO emission from the Cloverleaf quasar at a redshift of 2.5, increasing the previous maximum redshift in a quasar by an order of magnitude. The detection of CO in a high-redshift quasar opens up the field of cosmological studies of star forming material in the early universe. Another example has been the detection through VLBI of compact OH line emission in an ultraluminous infrared galaxy, Arp 220, implying that the megamaser in that source is physically more compact than previously thought. This result holds great potential for future probes of the nuclear environment of such galaxies.

\(^1\)Boston University, Brandeis University, Dartmouth College, Harvard University, Harvard-Smithsonian Center for Astrophysics, MIT, Polytechnic Institute of New York, State University of New York at Stony Brook, Tufts University, University of Massachusetts, University of New Hampshire, and Yale University.
In the Fall 1993, the Division of Astronomical Sciences at the NSF appointed a panel of radio astronomers to review university-associated radio observatories including Haystack, in order to be prepared for anticipated constrained future budgets in astronomy. Haystack’s VLBI program was given high commendation and the accomplishment of the recent upgrade of the telescope was lauded by the panel. Although the panel noted that excellent science is being done at Haystack, it was recommended that the long term future of the Haystack telescope be assessed relative to newer large telescopes such as the Green Bank Telescope presently under construction. At the time of the review, only engineering test measurements at 3mm-wavelength were available from Haystack, which weakened the Observatory’s standing relative to the other mm-wavelength telescopes being reviewed. As noted above, important measurements have now been conducted during the first observing season this past winter, and the case for future operations of the telescope is being argued strongly in grant requests submitted to the NSF. To meet the stringent budget constraints imposed by NSF guidelines to ramp down the operations of the telescope over the next three years, the costs of operations at Haystack have been reduced and further automation and a simplified user interface have been implemented.

In astronomical VLBI, Haystack’s priority is being placed on the coordination of a mm-wavelength VLBI array, composed of an international set of 11 radio telescopes, capable of observations at 50 microarcsec resolution. The effort involves technical support of the telescopes, data processing on the Haystack correlator, development of post-processing techniques to produce radio source images, as well as scientific research. This effort will open an easy access path for the astronomical community to mm-wavelength VLBI, and the scientific projects that will be conducted with such an array include the study of Active Galactic Nuclei, the Galactic Center, and maser emission.

Work has continued during the past year on technological developments for VLBI applications, both in high data rate recording (> 1 Gbit/s) and in high speed data processing. An advanced correlator, the Mark IV system, has been designed and will use a new specialized VLSI computer chip for this purpose. Several national and international programs are collaborating and supporting the development of the Mark IV system at Haystack, including NASA and the US Naval Observatory for geodetic and time services applications, the Smithsonian Institution for submillimeter-array processing, the Joint Institute for European VLBI for its planned large correlator, the Netherlands Foundation for Radio Astronomy for the Westerbork array at Dwingeloo, and the Institute for Applied Geodesy in Germany for geodetic data processing at the Max Planck Institute. Strong industrial involvement exists in these technology projects.

In our radar programs, the Haystack auxiliary radar constructed by Lincoln Laboratory has reached operational status and, together with the main Haystack antenna, is used for imaging satellites and characterizing space debris of a few centimeters in size. Our atmospheric sciences group has conducted bistatic radar observations with the University of Western Ontario whose antenna received Millstone Hill radar signals scattered coherently from structures in the earth’s ionosphere at altitudes of 100–150 km. In another experiment, a set of navigation receivers were fielded north of Millstone to make tomographic observations of small scale structures in the ionosphere, in collaboration with scientists from the Former Soviet Union. Comparison of the observations with simultaneous measurements using the Millstone Hill radar successfully validated the tomographic technique. Emphasis in the group’s research has also been given in the past year to the study of geomagnetic storm effects on the earth’s ionosphere, with the first observation of neutral winds exceeding 100 m/s near 120 km during a storm event. Moreover, the program to host several visiting scientists from the Ukraine and Russia to collaborate on studies of the earth’s atmosphere has been successfully initiated.

Haystack educational programs have continued successfully during the past year. Graduate and undergraduate students have utilized the Haystack instrumentation for research projects, and the summer undergraduate internship program involved 10 students each year. The Young Scholars program, aimed at pre-college level students, involved 30 students from the local area in a three-week summer program followed by an academic year project and special mentorship by our staff. Special activities have been coordinated with the local area science teachers to enrich their curriculum and expand the exposure of their students to science and mathematics.

Finally, our affirmative action objectives to enhance the representation of women and minorities among our research staff positions have been fulfilled by the hiring of a woman to fill the only permanent full-time position that became available this year, namely that of a high power transmitter engineer at Millstone Hill.

JOSEPH E. SALAH
MISSION
The MIT Supercomputer Facility (MITSF) became available to the MIT community in July 1989. The facility is supported by a research grant from Cray Research Incorporated (CRI) and from user fees. The goal is to provide, through coursework and research at both the undergraduate and graduate levels, education in and by the application of supercomputing; to combine CRI world-leading supercomputers with MIT's unique educational and computing environment to mold curricula that exploit, and advance, the frontiers of computational science. The mission fulfilled implies students that are much better versed not only in their chosen fields, but also in an advanced technology which will be increasingly critical in their future development and their professional effectiveness.

HARDWARE
(1) "edtoo," a Y-compatible CRAY X-MP EA/464 with four processors, 64 megawords of memory, a "virtual" 128 MWord Solid-State Device and over 30 gigabytes of disk space; (2) "junior," a CRAY X-MS/116 with one CPU, 16 megawords of memory, and four gigabytes of disk space.

SOFTWARE

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THE TRANSPARENT COMPUTING MODEL
An important part of the educational supercomputing environment is the Transparent Computing Model (TCM). TCM is a system that provides Athena users with access to CPU cycles on the MITSF CRAY X-MP EA/464 and CRAY X-MS/116 without requiring them to have logins or permanent storage on either system. It consists of a user-extensible parser that translates local commands into their CRAY equivalents; a client program responsible for describing the user's local environment and passing signals; a server program which enforces administrative limits, recreates the user's environment, and executes the user's request; and several support programs, including a hierarchical help facility and a utility to extract usage reports. Two modes of access are possible: transparent mode, in which a user's local (Athena) file systems are NFS-mounted on the CRAY; and opaque mode, in which a temporary home directory is created on the CRAY that the user may transfer files to using the standard File Transfer Protocol (FTP) utility. Either mode allows the development of seamless (transparent) distributed applications, and either mode allows access to the "native" CRAY user interface. Currently, TCM users are restricted to using 15 minutes of CPU cycles in a 24-hour period, and eight megawords of memory. Access is restricted to Athena users via Kerberos authentication. During the first six months of 1994, TCM was accessed 16,784 times, involving 537,078 CPU seconds, 358 users, and the completion of 16,092 jobs.

STAFF
The Co-Directors of the MITSF are Professors Robert A. Brown and Anthony T. Patera. The Facility is run by Administrator Edward Andrews. Marilyn Nash, previously employed as Senior Secretary, was replaced by Jackie Karovic in January 1994. Technical consultation is provided by Dr. Firooz Partovi and Leslie Finck. In addition to MITSF personnel, MITSF benefits from MIT Information Systems (I/S) personnel provided as part of an internal MITSF-I/S Service Level Agreement. This Service Level Agreement covers all aspects of operation of the CRAY X-MP.

DEPARTMENTAL USAGE
To date the following departments have incorporated supercomputing in conjunction with coursework and research projects at the Institute: Center For Advanced Engineering, Aeronautics and Astronautics, Architecture, Biology, Brain and Cognitive Sciences, Chemical Engineering, Chemistry, Civil Engineering, Earth and Planetary Science, Economics, Electrical Engineering, Haystack Observatory, Health Sciences and Technology, Lincoln Laboratory, Laboratory for
Laboratory, National Magnet Laboratory, Nuclear Engineering, Ocean Engineering, Physics, Plasma Fusion Center, Sloan School of Business Management, Center for Space Research, Whitehead Institute, and Woods Hole Oceanographic Institute.

EDUCATIONAL USAGE
Since its inception, the MITSF is able to report supercomputing usage by 62 faculty (terms), 84 teaching assistants, 831 undergraduate students, and 1,271 graduate students, for a total of 2,248 users, incorporating supercomputing in coursework. The following is a partial list of courses and seminars in which supercomputing has been introduced:

Aeronautics and Astronautics
  Advanced Computational Fluid Dynamics
  Turbulence and Random Processes in Fluid Mechanics

Architecture
  Computers and Architecture
  Introduction To Building Technology

Brain And Cognitive Science
  Seminar On Motor Learning

Chemical Engineering
  Applied Quantum Mechanics
  Gas Diffusion in Polymers
  Integrated Chemical Engineering I
  Numerical Methods Applied to Chemical Engineering
  Structures In Properties of Matter

Civil Engineering
  Advanced Structural Analysis

Electrical Engineering and Computer Science
  CMOS Analog Integrated Circuit Design
  Design of Analog MOS LSI
  Poisson Project
  Simulation of Analog Circuits Using HSPICE
  Solid State Circuits

Health Sciences and Technology
  Biological Control Systems
  The Cardiovascular Simulator Project

National Magnet Laboratory
  Biological and Medical Applications of Radiation and Radioisotopes

Mechanical Engineering
  Convective Heat and Mass Transfer
  Advanced Fluid Mechanics
  Conduction and Change of Phase Heat Transfer
  Computational Fluid Dynamics
  Computer Methods In Dynamics
  Finite Element Applications in Mechanics and Materials
  Introduction To Heat Transfer
  Methods of Engineering Analysis
  Theory and Practice Of Continuum Mechanics

Nuclear Engineering
  Nuclear Engineering Design
  Statistical Processes and Atomistic Simulations

Ocean Engineering
  Analyzing the Stress Distribution of Welded Structures
  Computational Geometry
  Marine Hydrodynamics (I and II)
  Ocean Seismic-Acoustics
  Panel Methods for Marine Hydrodynamics
  Using the Cray to Compute Water Waves
  Introduction to Naval Architecture

Physics
  Computational Physics

Mathematics
  Topics In Applied Mathematics

School of Management
  Advanced Financial Economics III
  Security Prices/Options and Futures Markets

RESEARCH USAGE
Since its inception, the MITSF has tracked supercomputing usage of 218 faculty, 192 staff, and 559 students. Lincoln Laboratories has engaged 130 users and Woods Hole 12 users. This results in a total of 1,161 users for MIT-related research. Average machine utilization for fiscal year 1994 was 29%, down from 38% in FY93.

OUTSIDE USERS
The MITSF also provides supercomputing cycles to several commercial organizations. The following companies were users of the CRAY X-MP EA/464 in FY94:

ALLISON GAS TURBINE DIVISION
AKZO CHEMICALS
EXA CORPORATION
MITRE CORPORATION
MOBILE SOLAR ENERGY
NEKTIONICS
RAYTHEON INCORPORATED

CLOSURE
The MITSF will close on June 30, 1994. The necessary upgrade to a current generation vector supercomputer is prohibitively expensive; less expensive parallel supercomputers are, at present, not appropriate as an Institute-wide general purpose resource.

ANTHONY T. PATERA
ROBERT A. BROWN
During the past year the Nuclear Reactor Laboratory (NRL) continued its joint interdisciplinary activities with both MIT and non-MIT collaborators, including academic departments and interdepartmental laboratories and a number of other universities, schools, and nonprofit research institutions, such as teaching hospitals. These joint research or teaching and training activities cover a wide spectrum in the life and physical sciences and in engineering, including development of a brain cancer therapy, nuclear engineering, computer control of reactors, training in reactor operations, dose reduction in power reactors, and radiochemistry and trace analysis applied to the health effects from energy use, nutrition, earth and planetary sciences, archeology, environmental studies, and nuclear medicine. Since the end of the current operating license is approaching, a panel of MIT and non-MIT membership is examining the value and cost of the MITR reactor project, including a projection for the period after the current license ends in 1996.

Especially noteworthy developments were the successful operation of the in-pile slow strain tensile testing facility which successfully completed the first ever actively loaded slow strain test in an in-pile autoclave at BWR conditions, and the continued program in joint research with Tufts–New England Medical Center on the treatment of brain cancer utilizing the boron neutron capture method. The latter project has reached the clinical trial phase and has had a doubling of its budget after the latest site review. A major new activity to carry out nuclear transmutation doping of semiconductor grade silicon single crystals was initiated and currently NTD silicon crystals are being produced at a rate of ~ 10 tonnes/year, with a gross income to the MITR of more than $1M/year.

NEUTRON BEAM TUBE RESEARCH
The prompt gamma neutron activation analysis facility has been upgraded again. Its sensitivity now exceeds the sensitivity, by a factor of 2-3, of other prompt gamma facilities located at reactors of up to twice the power of the MIT Research Reactor (MITR-II). A new initiative in neutron beam tube research has been proposed and, as a first step, neutron reflectometry will be developed by a faculty team headed by a new junior faculty in Nuclear Engineering.

ENVIRONMENTAL RESEARCH AND RADIOCHEMISTRY
Professor Frederick A. Frey, Department of Earth, Atmospheric, and Planetary Sciences, and research colleagues, MIT graduate students, post-doctoral fellows, and visiting scientists utilize the MITR-II for trace element analyses of geologic materials by neutron activation analysis (NAA).

A major result that has emerged from recent research is that there are significant geochemical differences between coeval and adjacent volcanoes in the chain of Hawaiian volcanoes that form as the Pacific plate migrates to the northwest over a magma source in the mantle. This result places significant constraints on the hypothesis that these large volcanoes are derived from an ascending mantle plume.

During 1993-94 Dr. Ilhan Olmez continued a major attempt to increase the utilization of NRL by making its neutron activation analysis facilities and expertise available to industry, other universities, private and governmental laboratories, and hospitals in the area (as described in The MIT REPORT, May 1986). Research and/or service-oriented collaborations were established with several MIT research laboratories as well as with other educational and research institutions in addition to those established in previous years, including the University of Washington; The University Hospital, Boston, MA; Texas A&M University; the International Atomic Energy Agency, Vienna; and Brandeis University. Commercial organizations that utilized the NAA expertise of NRL during the past year were Physical Sciences Inc., Andover, MA; the Empire State Electric Energy Research Corporation (ESEERCO), NY; the Electric Power Research Institute (EPRI), Palo Alto, CA; NRC Inc., Newton, Massachusetts; TEXTRON Defense Systems, Everett, MA; CARNOT, Tustin, CA; CONSOL Inc., Library, PA; H. C. Stark, Inc., Newton, MA; Spire Corporation, Bedford, MA; and Radian Corporation, Houston, TX.

Within MIT, research support has been provided to several departments. This research support includes: the study of the role of metallic and organo-metallic groups in the final properties of the polymeric implant for Professor E. W. Merrill (Department of Chemical Engineering); determining uranium concentrations in various mica samples for Dr. Janez Megusar (Materials Processing Center); analysis of various environmental and biological samples for trace and toxic metals for Professor William G. Thilly (Center for Environmental Health Sciences); and analysis of peat cores for trace metals for Professor Harold F. Hemond (Department of Civil and Environmental Engineering).

Dr. Olmez has been actively engaged in a number of environmental research projects. A three-year $500,000 grant which was obtained from the Empire State Electric Energy Research Corporation to study the current toxic metal levels in atmospheric particulate materials and wet deposition in upstate New York continued.

Funding continued in the past year for the study of the fate of mercury in the environment (ESEERCO, $600,000/three years).
A new course, 22.78 Nuclear Techniques in Environmental Analysis, was offered by Dr. I. Olmez and Professor N. K. Aras, a visiting Fulbright scholar. There are currently three Ph.D. candidates working on projects in environmental research.

A number of other research applications of NAA are summarized in a subsequent section, Reactor Irradiations and Services for Research Groups outside MIT.

NUCLEAR MEDICINE
All of the technology is now in place to permit initiation of clinical treatment of neutron capture therapy for refractory tumors such as melanoma, brain metastases, and glioblastoma multiforme. All eleven approvals required by institutional and governmental boards before these trials can begin have now been received. Initiation of clinical trials is imminent.

The MIT Reactor also supports nuclear medicine programs conducted by several hospital and radiopharmaceutical groups outside MIT. Included in this work is the successful program in radiation synovectomy for rheumatoid arthritis at the Brigham and Women's Hospital.

RADIATION HEALTH PHYSICS
The NRL supports a subdiscipline in the Nuclear Engineering Department (NED), Radiation Health Physics, by providing relevant research opportunities and a specially designed laboratory/demonstration course. This course, 22.09-22.59 Principles of Nuclear Radiation Measurement and Protection, is appropriate for all students in NED. The Radiation Health Physics program was originated by Professor Otto K. Harling at the NRL and is now under the direction of Professor Jacquelyn C. Yanch, NED. The program is designed to produce graduates who are well educated in nuclear engineering fundamentals as well as in the basics of radiation measurement, management, and protection. Basing this activity at the NRL is particularly appropriate since the MITR provides excellent opportunities to learn many aspects of this subfield in a realistic environment. Support for graduate students has been obtained from the Institute of Nuclear Power Operations, from several nuclear utilities, and several NRL research projects.

COMPUTER CONTROL OF REACTORS
Dr. John A. Bernard of the NRL and Professor David D. Lanning, Nuclear Engineering Department, continued studies on the closed-loop, digital control of nuclear reactors during both steady-state and transient operation. Assistance was received from Professors Allan F. Henry and John E. Meyer (NED). A general set of control principles, based on reactivity constraints and intended for nonlinear conditions, was deduced and experimentally demonstrated on the MIT Reactor during 1983-1985. This approach is unique in that it is based on the general equations of reactor dynamics rather than on measurements of specific response characteristics. The 'reactivity constraint approach' was licensed by the United States Nuclear Regulatory Commission (NRC) for general use on the 5 MW MIT Research Reactor in April 1985. As a result, closed-loop control experiments can be performed without a priori restrictions on the associated reactivity. Among the concepts developed and experimentally tested on the MIT Research Reactor have been a rule-based controller, an on-line method for control law reconfiguration, period-generated control laws, model-based methods including feedforward control, and automated startup technologies. Present efforts include an experimental evaluation of flux synthesis methods for reactivity estimation, and control of reactors in spacecraft. This work is currently supported by the United States Department of Energy (DOE) and by the Sandia National Laboratories (SNL). It resulted in several publications during the past year. In addition, six major reports summarizing both the theoretical and experimental work performed in this area have now been issued. There are currently two theses in progress (one S.M. and one Ph.D.) on topics related to this research. Demonstrations of the technology are available by appointment.

DOSE REDUCTION AND COOLANT CHEMISTRY STUDIES FOR NUCLEAR POWER REACTORS
A major study to optimize coolant pH for minimized radioactive material transport in pressurized water reactors (PWRs) was completed in 1994. This study was funded by the Nuclear Power Engineering Center (NUPEC) of Japan at $1,882 million over a period of 4.5 years. Compact in-pile loops developed under earlier sponsorship by the Electric Power Research Institute and the Empire State Electric Energy Research Corporation were used for 3000-hour simulation runs under realistic PWR conditions. A complementary program to study radiolysis chemistry and radioactive nitrogen carryover in boiling water reactors (BWRs) also continued during this period. Sponsored primarily by Hitachi and Toshiba, this research generated data relevant to BWR cracking problems and turbine building dose rates. The effect of a number of coolant additives and their influence on radioactive N-16 carryover were thoroughly tested. Principal investigators are Professor Otto K. Harling (NRL), Professor Emeritus Michael J. Driscoll (NED), and Dr. Gordon E. Kohse (NRL). Others also participating are Dr. Ilhan Olmez (NRL); members of the MIT Reactor staff; Professors Ronald G. Ballinger, Scott A. Simonson, and David D. Lanning (NED); Dr. William Lindsay (an expert consultant in the field of reactor coolant corrosion studies); and a number of MIT students from the Nuclear Engineering Department. These projects utilize the MIT Reactor directly and provide much needed support for experimental research in nuclear engineering. It is expected that two to four graduate students will continue to be involved in this project.
A new program to study zinc injection in PWRs for dose reduction has begun with funding from Mitsubishi Heavy Industries and a Japanese utility group.

**IRRADIATION-ASSISTED STRESS CORROSION CRACKING**

This project continued under a $1.2M contract from the Tokyo Electric Power Company and with additional funding from the Electric Power Research Institute. The unique in-pile slow-strain testing rig has successfully operated in-pile and the first ever actively loaded tensile test in an in-pile autoclave was recently completed.

**SENSOR PROJECT**

The Sensor project is a continuing program complementary to the IASCC project described above. The irradiation rig has been demonstrated out-of-pile and funding for irradiation is being negotiated. Principal investigators are Professor Ronald G. Ballinger and Dr. Gordon E. Kohse, with support from the Dose Reduction and IASCC staffs.

Instrumented crack sensors and electrochemical potential sensors will be operated under simulated BWR conditions in the MITR-II core. The primary objective of the research is to demonstrate the effectiveness of hydrogen water chemistry in controlling irradiation-assisted stress corrosion cracking. This research will also contribute to a more general understanding of important IASCC variables: material composition and processing; water chemistry, including radiolysis chemistry; and irradiation damage.

**MITR RELICENSING AND REDESIGN**

With funding from MIT and from the USDOE, efforts to look at options for upgrading the MITR have intensified in the past year. Four senior Nuclear Engineering professors, several research staff, and more than ten students were involved in this effort during the last year. New core designs using two types of low-enriched fuel were explored, and a power increase for the current core was studied. Based on these studies, the best performance for a relicensed reactor can be attained by using the current core and a plate type silicide fuel. An increase in power to 10 MW from the current 5 MW also appears feasible with relatively minor changes to the current heat removal systems.

The MIT Administration has established a panel which is reviewing the cost and benefits of the MIT Research Reactor Project. A decision on the future of the project is expected later in 1994.

**REACTOR IRRADIATIONS AND SERVICES FOR RESEARCH GROUPS OUTSIDE MIT**

In nuclear medicine, the development and/or continuing production of radioisotopes for use by researchers at hospitals and other universities included: 1) production of Dy-165 for Dr. Clement B. Sledge of Brigham and Women's Hospital for research studies in the treatment of arthritis; 2) research activities by Professor Fred Bruenger of the University of Utah using solid state fission track detectors to analyze the plutonium content of bones; 3) investigations by Dr. McDonald Wrenn of the University of Utah using track etching techniques to determine the lower detection limit of uranium in water; 4) neutron activation analysis of brain tissue samples by Dr. Robert Brown, Department of Neurology at The Massachusetts General Hospital; 5) neutron activation analysis to evaluate air quality by Professor John D. Spengler of Harvard University; and 6) evaluation of holmium for arthritis treatments by Dr. Alan B. Packard of Children's Hospital.

In a number of other areas, also, reactor irradiations and services were performed for research groups outside MIT. Most of these represent continuations of previous research: 1) Mr. Frank V. Thome of the Sandia National Laboratories irradiated spacecraft electronic components in the fast spectrum facility to determine susceptibility to space radiation effects; 2) Dr. Alan P. Fleer of Woods Hole Oceanographic Institute used irradiation to determine natural actinides and plutonium in marine sediments; 3) Dr. Raju Raghavan of ATT Bell Laboratories is irradiating scintillation fluids to test the sensitivity of detectors used in neutrino research; 4) Ms. Ellen Burkhard of the New York State Health Department is using neutron activation analysis to assess air quality; 5) Dr. James Thompson of Oak Ridge National Laboratory is studying radiation hardening of superconducting material; and 6) Dr. Gerjian P. Van Bakel of Northwestern University is studying neutron damage of Ni-Al alloys. Additional NAA services, including many for research groups outside MIT, are reported above in the section entitled Environmental Research and Radiochemistry.

Whereas most of the above outside users pay for irradiation services at the reactor, educational institutions needing such services for their own academic or research purposes are assisted in this regard by the USDOE through its “Reactor Sharing Program.” A grant to MITNRL reimburses us for the costs of providing irradiation services and facilities to other institutions (including teaching hospitals and middle and high schools). Under this program 847 students and 120 faculty and staff from over 42 other educational institutions benefited from visits to and use of the MITR during the past year. Popularity of the sharing program continues to grow.

Research utilization of the MITR by other institutions under the Reactor Sharing Program during the past year has included: 1) use by Professors J. Christopher Hepburn and Rudolph Hon of Boston College to activate geological specimens and standards for the NAA of rare earth and other trace elements in studies of the geological development of the northeastern
For education of the general public and students at all levels in local and other New England schools, the reactor staff provides lectures and tours periodically throughout the year. One local university incorporated reactor visits and experiments into its regular course curricula, as follows: The University of Massachusetts, Harbor Campus, Professor Martin Posner, Department of Physics, Physics 603, 13 students, 5 visits.

An educational program to familiarize high school science teachers with the scientific, engineering, and medical uses of nuclear research reactors and to involve the teachers in typical applications and experiments, with a special lecture and demonstration by the MIT Radiation Protection Office, is also funded by the USDOE Reactor Sharing Program. Seminars of four and one-half hours each are typically held in the spring. This effort was augmented in 1994 by our sending staff to local schools.

AFFIRMATIVE ACTION
The NRL supports the affirmative action goals of the Massachusetts Institute of Technology. Of a staff of 35 there are currently six engineering and management positions held by minorities and women. The NRL participated in the USDOE's program for minority training in reactor operations, and one of our current senior reactor operators is a graduate of this program.

MIT RESEARCH REACTOR
The MIT Reactor completed its 36th year of operation, its 20th since the 1974-75 shutdown for upgrading and overhaul. The reactor normally operates on a Monday through Friday schedule. However, for the past year the reactor occasionally operated continuously (seven days per week) to support several major experiments related to the dose reduction studies. Also, much low power testing was performed for the neutron capture therapy program. On average, the MIT Reactor was operated 50 hours per week with 41 hours per week at its design power level of 5 MW. Energy output for the MITR-II, as the upgraded reactor is now called, totaled 315,200 megawatt-hours at June 30, 1994. The MITR-I generated 250,445 in the sixteenth years from 1958 to 1974.

To summarize briefly the reactor utilization described in more detail above, it was well utilized during the year, although still more experiments and irradiations can be accommodated due to the number and versatility of its many facilities. The reactor, as an integrated whole, continues to be used in a series of experiments designed to demonstrate the feasibility and advantages of reactor control by digital computer. Two pressurized loops for a major interdepartmental project on dose reduction for power reactors are installed in the reactor. A major project on irradiation-assisted stress corrosion cracking, initiated with United States and Japanese support, has also been installed. A new large project involving in-pile sensor testing continues with domestic and international support. The number of specimen irradiations was 778. There were 22 irradiations in the medical room, most in support of the neutron capture therapy program for the treatment of brain cancer and subcutaneous melanoma. Theses and publications on research supported by the reactor are running at about 10 and 65 per year, respectively. A total of 1105 people toured the MIT Research Reactor during 1993.

A project has been initiated for the neutron transmutation doping of single crystal silicon ingots in one of the reactor's horizontal throughports. Thus far, physics and engineering studies were performed to characterize the neutron beam and to determine the feasibility of uniformly irradiating the ingots with simultaneous translational motion over an interval of several days through the beam port. These measurements and design studies were done by the MITR staff. Based on these results a machine for the irradiation of ingots was designed, built, and installed. Operation began in 1994 and this project is now providing a source of base support to the reactor.

DOE continues as the supplier of fuel to university research and training reactors. Babcock and Wilcox (B&W), Lynchburg, Virginia, is the fabricator and is commencing production of another batch of fuel for the MITR-II.
INTRODUCTION
The Operations Research Center (ORC), established in 1953 as a first-of-a-kind interdepartmental graduate degree program, completed its 41st year of operation in 1993-94. The Center administers its own graduate programs and a varied research program of methodological and applied projects. This report summarizes the Center's 1993-94 activities and briefly reviews its educational, research and outreach programs.

FACULTY, STUDENTS, STAFF
Richard C. Larson, Professor of Electrical Engineering, and Thomas L. Magnanti, George Eastman Professor of Management Science, continued as Codirectors of the Center.

This year the ORC had 33 affiliated faculty and senior staff, with faculty drawn from the School of Management and the Departments of Electrical Engineering and Computer Science, Civil and Environmental Engineering, Ocean Engineering, Mathematics, Aeronautics and Astronautics, Mechanical Engineering, and Urban Studies and Planning.

The Operations Research Center offers two interdepartmental graduate degree programs, a PhD degree in Operations Research and a master's degree. During 1993-94, these programs enrolled 65 students — 38 PhD candidates and 27 SM candidates. The center conferred 18 master's degrees and 3 PhD's. Several other PhD theses were in the final stages of completion in the summer of 1994. For the fall term 1994, the ORC expects an incoming class of 16 students.

ACADEMIC PROGRAMS
The ORC's academic programs continue to be recognized as ranking among the very best nationally and internationally. The program, moreover, is repeatedly cited as achieving an excellent balance between applications and methodology.

In view of constraints imposed by its limited financial and space resources, the Center has determined that the size of its PhD program should remain at about the same size over the foreseeable future.

RESEARCH ACTIVITIES
The volume of research in the ORC represents but a small fraction of OR-related research carried out throughout the Institute by ORC-affiliated faculty, students and staff. Research activities spanned a wide spectrum of methodological topics and applications, ranging from small, unsponsored projects involving a single faculty supervising a student's thesis to much larger, sponsored programs involving several faculty/staff and students.

Methodological research includes such topics as mathematical programming and combinatorial optimization, solution methods for integer programming, interior point methods for linear programming; cluster analysis; parallel and distributed computation and algorithms; network flow algorithms; network design; probabilistic combinatorial optimization; deterministic and stochastic facility location; queueing theory under both static and dynamic conditions; equity in queueing systems; analysis of queueing networks; stochastic processes; classical and Bayesian statistics; and decision analysis and statistical decision theory.

ORC faculty are also currently contributing to several major areas of application including: flexible manufacturing systems; financial services; marketing; transportation systems; life-cycle modeling of municipal solid waste; air traffic control; public services, such as urban emergency systems; criminal justice; safety and risk analysis in air transportation, communication systems, nuclear engineering and epidemiology; remotely controlled queueing systems; scheduling of workers and work in 'service factories'; and industrial production and transportation logistics. This year several of the Center's faculty and students have been involved in the human genome project.
Several organizations sponsored research projects at the ORC during 1993-94, for example: the National Science Foundation; C.S. Draper Laboratory (several projects and Draper Fellowships); Department of Transportation (several projects); Federal Aviation Administration; Air Force Office of Scientific Research; Department of Energy; United Parcel Service Foundation; and the Whitehead Institute.

SENSE OF COMMUNITY
The ORC has always attempted to provide an environment that is responsive to the varied professional and personal needs of the OR community at MIT, and that builds upon diversity (including equal opportunity).

The Center's graduate students are diverse: they represent over 21 countries and, in keeping with the Center's tradition of seeking and attracting outstanding women, the number of female students has consistently averaged about 30%. The Center's primary support staff — two administrative assistants and one administrative officer — are all women, two African-American. This year the ORC's active affiliated faculty members included two women.

OUTREACH AND PROFESSIONAL SERVICE
In its effort to serve the professional community at large, the OR Center regularly undertakes a number of outreach activities.

This year, Boston was the host of a combined national meeting, attended by over 2000 professionals of the Operations Research Society of America and the Institute of Management Sciences. Several MIT faculty and staff played key roles in organizing this important meeting, including Dr. Donald Rosenfield, who served as the meeting's general chairman.

In conjunction with this meeting, in April the Operations Research Center celebrated its 40th anniversary as an MIT Interdepartmental Program with a gala cruise in the Boston Harbor that brought together over 230 of the center's alumni/ae and current faculty and students. As part of this celebration, the Center published a book of informal reminiscences.

The ORC offers professional courses during the summer session. It offered one such program, "Airport Systems: Strategic Planning and Detailed Design," during the summer of 1994.

The Operations Research Practicum continues to be an important vehicle of outreach and of providing students with valuable "hands on" experiences. The Practicum has successfully completed projects for a variety of local firms and organizations, including the Boston Museum of Science (early 1992) and the Scudder Mutual Fund Company (December, 1993). During the academic year 1993-94, the Practicum focused on a very special and complex set of operational problems for its host institution: MIT. The focus of the Practicum was on MIT's support services. The purpose was to identify a number of areas in which our approach and expertise could play a major role in improving the operation of the Institute. Specifically, we focused on three MIT administrative areas: parking for faculty, staff and students; food services; and Institute mail services. In all cases the students, working with Professor Richard C. Larson, worked intensely and cooperatively with the person or persons assigned to study these issues from the senior MIT administration. At least in the mail services and in the parking applications, the projects appeared to provide important analytical guidance and suggestions, and we believe that several of the ideas proposed are being implemented in some form.

The ORC Seminar Series was privileged to have many distinguished speakers from industry and academia this year. Among the many operations research professionals who made presentations were: Dorit Hochbaum (UC-Berkeley); Robert Vanderbei (Princeton); David Bell (Harvard); Linda Green (Columbia); Jim Bean (U. of Michigan); Bill Massey (AT&T); Mike Todd (Cornell); Charles McCallum (AT&T); Robert Herman (U. of Texas); Egon Balas (Carnegie-Mellon); Michael Caramanis (Boston Univ.); Paul Glasserman...
(Columbia); Tom Luo (McMaster University); Jonathan Caulkins (Carnegie-Mellon); and Andrew Conn (IBM).

**PROFESSIONAL ACTIVITIES**
The ORC-affiliated faculty continue to assume positions of leadership within the Operations Research and Management Science Community. This past year, Professor Larson served as President of the Operations Research Society of America and Professor Bitran served as Editor-in-Chief of the journal *Management Science*. Many other members of the faculty served as committee chairs for professional societies and in other editorial capacities in the top professional journals.

THOMAS L. MAGNANTI
RICHARD C. LARSON
Codirectors
Plasma Fusion Center

The primary objective of the Plasma Fusion Center is to provide research and educational opportunities to develop a basic understanding of plasma behavior, and to exploit that knowledge by developing useful applications. The central focus has been to develop a science and engineering base for fusion power; however, as can be appreciated from the research highlights in this report, applications involving plasmas are numerous and diverse. A recent example is the significant growth of programs in hot and cold plasma processing of waste materials.

The Plasma Fusion Center (PFC) is recognized as one of the leading university laboratories involved in the science and engineering aspects of magnetic confinement fusion and plasma research. Its research programs continue to produce significant results on several fronts: (a) experimental confinement research on the Alcator C-MOD tokamak (investigations of the stability, heating, and transport properties of plasmas at high densities, temperatures and magnetic fields), and collaborative efforts on other tokamaks in the United States and worldwide; and (b) the basic physics of energetic plasmas (plasma theory, RF heating, nonneutral plasmas and coherent EM wave generation, development of high-temperature plasma diagnostics, and basic plasma experiments; and (c) a broad program of technology and engineering development (e.g., magnet systems, superconducting materials, fusion environmental and safety studies, advanced millimeter-wave sources, system studies of fusion reactors including operational and technological requirements, and plasma waste treatment systems).

Approximately 40 percent of the Center’s activities are associated with the Alcator C-MOD tokamak experiment, 40 percent with the research on superconducting magnet system components for future fusion devices, and the remaining 20 percent with the many other R&D activities.

The Plasma Fusion Center R&D programs are supported principally by the Department of Energy’s Office of Fusion Energy. There are approximately 315 personnel associated with PFC research activities. These include: 23 faculty and senior academic staff, 68 graduate students and 22 undergraduate students, with participating faculty and students from Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, Nuclear Engineering, and Physics; 97 research scientists and engineers and 43 visiting scientists; 33 technical support personnel; and 30 administrative and support staff.

The Plasma Fusion Center’s new high-field tokamak, Alcator C-MOD, started full operation in May 1993. It was designed with the capability to address a range of issues, foremost including ITER-relevant research topics, as well as physics issues affecting the design of an advanced (long pulse) tokamak fusion reactor. A particularly difficult problem for ITER is the design of a divertor, or heat removal system, which will exhaust several hundred megawatts of thermal power. Alcator C-MOD has an advanced divertor design, unique among presently operating tokamak experiments, incorporating many of the key elements in the present ITER design approach. Thus, the critical issues of particle and power exhaust are a central program focus.

PFC programs also support ITER in critical technology areas, including superconducting magnets and development of millimeter wave RF sources suitable for heating and driving current near the electron gyrofrequency. In the magnetics area, the PFC leads the US ITER Home Team magnetics effort in an extensive, internationally coordinated program of superconducting magnet development leading to construction of magnets on a scale and performance level well beyond that of present-day experience.

ITER is currently in a six-year Engineering Design Activities (EDA) phase, to which the four parties have each pledged 250 million dollars toward the R&D necessary to support the main design approach. A challenging facet of the EDA is that the design work is carried out simultaneously at three co-centers located in Garching-bei-München (Germany), Naka (Japan), and San Diego (USA). PFC personnel have key responsibilities at these sites. Ronald R. Parker has headed the design team at Garching for two years, and has recently made a decision to step down as PFC Director in order to renew his contract with ITER. Richard J. Thome, Head of the Fusion Technology and Engineering Division, has headed the magnetics design work at Naka for two years, and will also remain away from MIT for at least two more years. Two young mechanical engineers from the PFC, Zbigniew Piec and Rui Vieira, are also assigned to the ITER Joint Central Team at the Naka center.
During the absence of Drs. Parker and Thome, Dr. Dieter Sigmar has served as Acting Director of the PFC, and Dr. Joseph Minervini has served as Acting Division Head of the Fusion Technology and Engineering Division. During the search for a new Director to replace Ronald Parker, Dr. D. Bruce Montgomery is serving as Interim Director.

With this introduction as background, highlights of the past year's research are summarized below by each of the six PFC Divisions: Toroidal Confinement, Physics Research, Fusion Technology and Engineering, Plasma Technology and Systems, and Waves and Beams

TOROIDAL CONFINEMENT DIVISION
The toroidal confinement division, led by Professors Miklos Porkolab (1994, acting while Professor Ian Hutchinson is on sabbatical leave at the Joint European Torus (JET) in England), carries out experimental research on the Alcator CMOD tokamak which commenced operation in April, 1993 and continued on nearly uninterrupted until November, 1993. After an upgrading and maintenance period, during which the alternator flywheel was delivered from Germany and installed at MIT, operations recommenced in May, 1994. Two dipole type antennas were installed during the winter maintenance period, and the first of these has been energized and used for plasma heating at the 1.8 MW net power level. In October, the total RF heating power capability will be 4.0 MW at the sources, which should make more than 3 MW net power available in the plasma for heating, confinement, and divertor studies.

Impressive results have been obtained in the last year: (a) In the area of Ohmic plasmas, routine operation has been achieved at magnetic fields of 5.3 T, and plasma currents of up to 1.0 MA; both limiter and divertor operations have been used. (b) ICRF heating has been demonstrated at net powers up to 1.8 MW with the dipole antenna. (c) The so-called ITER-89P energy confinement scaling is followed for both ohmic- and RF-heated discharges under normal operating conditions (i.e., high magnetic field and plasma densities), which often exceed the expected Neo-Alcator confinement scaling observed in the circular Alcator-C plasmas. (d) The H-mode (or High-mode) of confinement has been obtained in both ohmic and RF heated plasmas, when the surface power density exceeds a critical value of the nB product (where B is the toroidal magnetic field and n is the electron density). The typical nB products in CMOD are typically 5 times higher than in other experiments. Later this year nB is expected to reach values expected in ITER. The confinement improvement under these conditions is typically a factor of two higher than in L-mode discharges despite the fact that CMOD is protected by molybdenum, rather than graphite, tiles. This has far-reaching consequences for future high performance tokamaks, and in particular, ITER. (e) Significant divertor research results have been obtained with both "dissipative" and "radiative" divertor operation demonstrated. These results have placed CMOD among the most important tokamaks in the world program and several laboratories and universities have expressed strong interest in collaborating with MIT. Particularly noteworthy is the interest expressed by the Princeton University Plasma Physics Laboratory (PPPL) in the areas of RF heating, divertor physics and diagnostics. In recognition of the importance of the CMOD program, DOE is planning to increase the budget from $14.5 M in FY94 to $16.8 M in FY95. Selected CMOD achievements of the past year are discussed below.

Operations and Engineering Group
This group is responsible for the operation, maintenance and future upgrades to the tokamak facility. Steve Fairfax heads the group of more than 50 engineers, supervisors and technicians. At present, typical pulses require 130 MJ of energy at peak powers of 240 MVA. The new 75-ton flywheel increases the available pulse energy to over 500 MJ. The normal problems of learning how to operate a large, complex facility have been greatly simplified by the distributed control system. Some statistics related to plasma operations follow: 2564 plasma shots were attempted since the start of plasma operations in 1993. Of these, only 157 shots failed, which resulted in a 94 % reliability factor.

RF Heating and Advanced Tokamak Section
This section, led by Miklos Porkolab (Yuichi Takase, Acting Head in 1994) implements and analyzes plasma heating using radio frequency (RF) power, including investigation of advanced tokamak physics (ATP) scenarios.

Typical ICRF heated discharge results: The target inner-wall limited plasma (elongation 1.5 at a line average density of $\tilde{n}=1.8 \times 10^{20}$ m$^{-3}$ with a minority hydrogen concentration of $\sim10\%$), shows stored energy increases from 52 to 85 kJ when injected with 1.65 MW of RF power; the electron temperature (at the top of sawteeth) as
determined from electron cyclotron emission increases from 1.7 to 2.8 kV; ion temperature (from the neutron rate) increases from 1.2 to 1.8 kV. Absorption efficiency is 80-100%, and the observed heating is consistent with the ITER-89P L-mode confinement scaling assuming complete absorption.

**Plasma Group**
The Plasma Section, led by Steve Wolfe, is involved in advancing the understanding of the tokamak configuration in the areas of transport (subgroup headed by Martin Greenwald) and MHD physics (Robert Granetz), as well as developing and implementing optimized control procedures for tokamak operation.

Excellent progress has been made in the past year. Routine tokamak operation, including both limited and diverted equilibria pulse lengths up to 1.5 s were obtained. Operation with either positive or negative toroidal field and current, and plasma elongations to 1.8 were obtained.

The most surprising transport result is that for parameters at which the L-mode scaling corresponds to higher confinement than the neo-Alcator, the energy confinement observed for ohmic discharges on CMOD seems to correspond to L-mode scaling rather than neo-Alcator scaling. L-mode confinement was also observed with ICRF heating to 1.8 MW.

Better confinement is observed during H-mode operation, obtained in single null diverted discharges with the ion V B drift in the direction of the x-point. H-modes have been obtained in both ohmic and ICRF heated discharges. With ICRH, H-mode transitions in inner wall limiter equilibria have been obtained. The transition threshold, expressed in terms of surface power density, is below or equal to the lowest values obtained on larger, lower field devices. This result is of particular interest, because the power density, magnetic field, and electron density on CMOD are all comparable to the values projected for ITER.

The deuterium pellet injector has been used to fuel CMOD discharges up to the density limit. Pellet-induced enhanced particle confinement has been observed.

Vertical (axisymmetric) instability growth rate studies have been carried out for a range of elongations, and other MHD phenomena have been studied. An extensive investigation of disruptions has also begun, including "halo" current effects. Learning to minimize such disruptions and avoid potential excessive forces on the vacuum vessel and internal hardware is in process.

**Experiments Section**
This group focuses on studies of edge physics (Bruce Lipschultz), advanced plasma diagnostics (James Irby) and other experimental techniques for understanding and improving plasma performance. During 1993, the CMOD program contributed importantly to tokamak edge plasma physics by developing a dissipative divertor operation: The power diffusing from the confined plasma into the Scrapeoff Layer (unconfined field lines diverted from the confined region and flow to heat-load bearing plates) was dissipated utilizing radiation and charge-exchange processes before reaching the plates. This mode of operation is similar to a "flame-front" where the "flame" is not allowed to touch material surfaces. This is extremely important for the tokamak concept in order to deal with power losses while keeping the confined plasma clean and the divertor plates from eroding. The physics of this mode of plasma operation is under study.

Several advanced diagnostics are under development: Shearing interferometer (for fluctuation measurements), 2-D detector spectrograph (simultaneous spatial and spectral information for impurity source rate measurements), and an "Omegatron" probe (Z/impurity spectrum analyzer).

Collaborations with researchers at the Joint European Torus (fluid code modeling of the edge plasma), Princeton Scientific Instruments with Princeton U. (D. Dimock - Thomson scattering of the edge plasma), Science Research Laboratory (S. Fulghum - edge fluctuation measurements), U. of Maryland (H. Griem, B. Welsh - spectroscopy), Johns Hopkins University (M. Finkenthal, M. May - EUV spectroscopy), ENEA-Frascati Italy (F. Bombarda - X-ray spectroscopy) and Oak Ridge National Laboratory (C.H. Ma - polarimetry) continue to be important.

**PHYSICS RESEARCH DIVISION**
This section discusses progress made on smaller-scale physics-oriented experiments, novel diagnostic development, collaborative experiments on non-MIT tokamaks, and fusion theory research.
Phase Contrast Imaging on DIII-D

The Phase Contrast Imaging (PCI) diagnostic has been operational on the DIII-D tokamak during fiscal years 1992 through 1994. Full-time personnel include one graduate student (S. Coda) on location at General Atomics, supervised by M. Porkolab. General Atomics provided technical and engineering support in the early fabrication stages. This system generates images of the density fluctuations at the plasma edge with a radial resolution of 0.5 cm, with excellent sensitivity ($\sim 10^9$ cm$^{-3}$) and broad bandwidth (100 MHz). The two main motivations for this diagnostic, i.e. studies of low-frequency turbulence and ICRF waves, are relevant to the topics of confinement and current drive, respectively, which lie at the core of both the DIII–D and U.S. magnetic fusion programs. Research with the present diagnostic configuration has focused on low-frequency edge turbulence. Much data was collected during the 1993 experimental campaign, directed primarily to investigating the physics of the L– to H– mode transition.

X-Ray and γ-Ray Experiments Group

The X-Ray and γ-Ray Experiments Group (Richard Petrasso) expanded its work in both theoretical and experimental physics. In two Physical Review Letters in 1993 graduate student Chikang Li delineated some of the basic properties of moderately coupled plasmas, (plasmas that occur in the interior of stars and in inertially confined fusion). These have relatively high electron densities ($n \geq 10^{23}$ cm$^{-3}$) and low electron temperatures ($T \leq 10^4$ eV). The theoretical effort is now directed at enhancing understanding of these plasmas' properties through improved calculations of characteristic relaxation times and transport coefficients (e.g. the thermal conductivity). This work comprised Chikang Li's Ph.D. thesis, and continues as his postdoctoral research. His work recently garnered significant attention in a comprehensive feature article in Science News (8 Jan. 1994) entitled "Simply Plasma."

Two other MIT graduate students work on x-ray and γ-ray tokamak experiments, Dan Lo on Alcator CMOD, and Jim Lierzer at TEXT tokamak (in Austin, Texas). Lo has fielded a diagnostic to detect charged fusion products from deuterium-deuterium fusion, ion temperature can be inferred from these products. At TEXT Lierzer has fielded 2 x-ray imaging arrays. These arrays are being used to study both energy and particle transport and to determine the plasma position since the plasma is a copious emitter of x-rays. In a closely related effort, Dr. John Coleman is developing a new class of small, radiation resistant x-ray detectors based on diamond photoconductors that could comprise the individual picture elements needed for future x-ray imaging arrays.

Professor Kevin Wenzel and graduate student Dimitrios Pappas, in collaboration with colleagues at Lawrence Livermore National Laboratory, are developing a novel γ-ray spectrometer based on a pair-production process which would be sensitive to 16 MeV γ-rays that emanate from deuterium-tritium fusion, to be used to record the time evolution of the deuterium-tritium burn in inertially confined fusion (ICF) pellets.

Graduate student Cristina Borris, with Professor Wenzel, examined the nuclear activation generated in the Alcator CMOD limiter. This is directly related to a class of high energy electrons ($E \sim$ MeV) that can induce, via photonuclear effects, nuclear activation. These electrons, produced during the plasma discharge, strike the limiter because of their high energy and poor confinement.

In another ICF effort with colleagues at the University of Rochester, graduate student Damien Hicks and Dr. C. K. Li are building a diagnostic to measure, through charged particle spectroscopy, the effective confinement and density within the fusion pellet. Regions of high density - up to ~ 300 g/cm$^3$ - are created when the pellet is imploded by simultaneously illuminating it with 60 laser beams.

In two review articles in Nature in 1994, Richard Petrasso summarized the progress and challenges that confront both inertial and magnetic confinement fusion.

Advanced Tokamak Studies

Current profile modification provides a means to improve plasma stability and confinement properties. In a steady state tokamak reactor the plasma must be maintained by non-ohmic means and the current profile would be determined by the current drive techniques chosen. Collaborative current profile modification experiments include modelling and data analysis on the TFTR and PBX-M facilities at the Princeton Plasma Physics Laboratory [MIT (Jay Kesner), Columbia University and Princeton Plasma Physics Laboratory]. This collaboration has pioneered studies of low-current high poloidal beta tokamak plasmas in DT fusing plasmas.
The experimental goal was to demonstrate high fusion reactivity and good alpha confinement in high poloidal beta "advanced tokamak" DT plasmas with relatively low plasma current (about half the current used in other TFTR experiments). Fusion grade plasmas with reduced magnetic shear (i.e. elevated values of the axial safety factor, \(q(0) \leq 1.3\)) that may be more unstable to alpha driven toroidal Alfvén mode instabilities were produced.

The MIT-Princeton collaboration on the PBX-M tokamak (Stan Luckhardt, Jay Kesner, and postdoctoral fellows Steve Jones and Franco Paoletti) was initiated four years ago to test the concept that RF current drive and heating might be used to improve the stability of tokamak plasmas with high beta and high poloidal beta values. In the PBX-M experiment lower hybrid current drive (LHCD), neutral beam heating, and ion Bernstein wave heating to control of the plasma current, density and pressure profiles are utilized. In the past year these experiments have produced several significant findings: 1) accurately measuring the spatial distribution of the current carrying energetic electron population and determining the spatial transport coefficients in lower hybrid current drive experiments. Results of these experiments were presented in an invited paper at the 1993 Plasma Physics Divisional Meeting of the American Physical Society (APS). 2) Using an electron cyclotron emission diagnostic that MIT has developed, ballooning modes have been detected in PBX-M. As part of the MIT/PPPL collaboration a novel multichannel cyclotron emission detector was designed to detect spatially localized magnetic instability activity caused by MHD ballooning modes. These experiments were the core of a student Ph.D. thesis.

One of the ubiquitous plasma instabilities affecting tokamaks is the sawtooth mode. A novel and unexpected phenomenon observed in lower-hybrid experiments on PBX-M was the prompt stabilization of this mode on a few milliseconds' time scale. Further data analysis and theoretical work (in collaboration with S. Migliuolo of the PFC) led to a proposed new stabilization mechanism involving the lower-hybrid ponderomotive force. This represents the first experimental and theoretical identification of this type of interaction between lower hybrid waves and MHD modes.

**Versatile Toroidal Facility (VTF)**
The Versatile Toroidal Facility (Stanley Luckhardt and graduate student Dexter Beals) is a toroidal plasma device which confines plasma in a helical magnetic field configuration named the Helimak. Plasmas created in the Helimak exhibit many properties of the divertor plasma in future large tokamaks such as ITER. VTF is unique in having very long and variable magnetic connection length, \(L_m = 10-100\) meters. In VTF the plasma is generated and heated by hot cathode electron beam injection and by electron cyclotron resonance heating.

Recent experiments have concentrated on improved measurements of plasma density and temperature variations parallel to the magnetic field. Measurements with a new scanning Langmuir probe revealed a substantial gradient of plasma density parallel to the magnetic field. Such gradients are predicted by divertor theory to result from collisional friction between plasma ions and a background neutral gas. Measurements are consistent with this interpretation. This work was part of Dexter Beals' master's thesis, (EECS).

**Ionospheric Plasma Research Group**
As a funding member of NPRSC, the PFC Ionospheric Plasma Research Group (Min-Chang Lee and students) has conducted radar experiments on the radio reflectivity of lightning-induced plasmas with MIT S-band and C-band meteorological radar on campus and at Millstone Hill UHF radar. The goal is to develop advanced radio and plasma technology for radio communications and space surveillance. This experimental work together with that of other NPRSC members' provides the scientific basis for the construction of a large antenna array in Alaska, sponsored by the Department of Defense. A paper entitled "Radar studies of lightning-induced plasmas with potential applications to radio communications and space surveillance" presented by graduate student Ms. Y.R. Dalkir at the 1993 USNC/URSI National Radio Science Meeting was first in the Students' Prize Paper Competition. This paper was published recently in *Radio Science*. Considerable effort has been made to develop a simple but reliable model of ionospheric plasma turbulence for satellite communications and geodesy, improving flight safety in air traffic control and geodesic accuracy. This model relies heavily on ionospheric plasma heating experiments at Arecibo, Puerto Rico for controlled studies of plasma turbulence. Laboratory experiments with VTF have greatly contributed to the understanding of plasma turbulence occurring in space plasmas or as a consequence of RF wave particle stimulation.
Chaos
Astrophysical plasmas (Paul Linsay) are an interesting place to look for nonlinear dynamics. In collaboration with Kevin Short of the MIT Mathematics department, Brian Kenny of the University of Western Australia, and Richard Manchester of the Australian Telescope National Facility, CSIRO, chaotic time series and their sources have been sought from the Vela and PSR J0437-4715 millisecond pulsars. These pulsars have a very high signal-to-noise ratio making them good candidates for analysis. Although a chaotic nonlinear system appears to be random and uncontrollable, there is underlying structure that permits feedback control to eliminate the chaotic motion. Feedback is being studied in some simple dynamical systems to understand the control. The control signals can be very small and do not modify the system dynamics significantly the way traditional linear feedback systems do.

Fusion Theory and Computations
The PFC Theory group (Dieter Sigmar) discovered a new method to remove the helium ash diluting the core of an ignited tokamak plasma, by applying strong frequency chirping of Alfvén waves. If theoretically suitable Alfvén waves can be launched practically, this discovery will have a far-reaching impact leading to a desirable size reduction in the present ITER device design. The quest for a steady state, advanced tokamak operating regime has been advanced through collaboration with numerical specialists from the Keldysh Institute for Applied Mathematics in Moscow who provided a suite of MHD stability codes extending across the magnetic separatrix. Collaborations to apply the codes to Alcator, ITER, and TPX-like tokamaks, in search of stabilization of the external kink modes in plasmas with high self-generated ("bootstrap") current fractions are in place. In the area of theoretical plasma turbulence, a novel idea was advanced to generate a sheared toroidal flow pattern in the tokamak using externally applied RF waves. This idea may be realized and tested in Alcator CMOD. An important focus is on developing analytical and numerical models of the plasma in the open field line region of the CMOD divertor chamber as a scale model for ITER. Reducing the exhaust-heat flow impinging on the divertor target plates has been attacked through the new insight that the inertial force generated by $E \times B$ flows couples a Reynolds stress component parallel to the open magnetic field lines into the momentum balance capable of sustaining a desirable "detachment" of the plasma from the divertor plates, an effect seen in Alcator CMOD even at moderate densities where radiation and charge exchange losses cannot protect the plates. At higher plasma and neutral densities, a novel idea has been incorporated into a Navier-Stokes code for the neutral particle fluid coupled to a standard plasma fluid code describing the charged particles, showing that vortex formation of the neutral fluid carries a major part of the incoming plasma heat flow across the magnetic field to the sidewalls of the divertor chamber thus protecting the plates.

The RF Theory group (Prof. Abraham Bers) has discovered a way to increase to as much as 100% the mode conversion efficiency of fast Alfvén waves to ion Bernstein waves for noninductive current drive of advanced tokamaks. A new model was also developed to understand the saturation of the stimulated Raman scattering in laser plasma interactions, in accord with inertial confinement fusion experiments at Livermore.

Prof. J. Freidberg and graduate student A. Shajii, who are supporting the Engineering Division, have developed an analytical theory-based model of superconducting quench protection in cable-in-conduit conductors for ITER magnets.

Physics of Thermonuclear Plasmas
The research effort focuses on understanding and theoretical formulation of the physics of plasmas under fusion burn conditions. In the past year interpretation of a phenomenon called the "Isotopic Effect," pointed out early in the Alcator program, was confirmed in other experimental facilities, and in particular in deuterium-tritium plasmas in the TFTR at Princeton. The phenomenon involves an increase in energy confinement properties when plasma composition changes from hydrogen to deuterium or to deuterium-tritium.

A main objective of the TPX device, the major U.S. experimental facility considered for construction at this time, is the investigation of the so-called second stability region for plasmas with relatively high pressures, that are comparable to that of the confining magnetic field. Identifying (and naming) this new stability domain in 1977-78 and determining thereafter the most reasonable path to reach it has been a major contribution of this group. During the past year convincing evidence supporting the second stability regime has come from experiments carried out in the D-III-D device at San Diego and the TFTR device at Princeton.
The Ignitor program has been the first proposed and devised to demonstrate the possibility of reaching ignition conditions on the basis of known plasma physics and existing technology. An important step in the progress of this program is being accomplished by the completion during the current year of the construction of the full scale prototypes of the main components of the machines in Italy. As in the case of the Alcator program, the technological solutions found for this device are expected to have a significant impact on future experiments.

Two prizes were received by Professor Bruno Coppi in late 1993: the European Italgas Prize for Research and Innovation, and the Special Prize for Culture (Scientific Research) by the President of the Italian government.

RF Interactions and Modeling Group

A state-of-the-art simulation code has been developed by Paul Bonoli (in collaboration with Professor Miklos Porkolab) to compute self-consistent MHD equilibria in the presence of non-inductively driven currents. The model includes driven currents by neutral beams, lower hybrid waves, fast magnetosonic waves, and the bootstrap effect. The lower hybrid (LH) module in this code has been refined extensively and benchmarked against the results of steady state LH current drive in the Tokamak de Varennes (collaboration with Dr. V. Fuchs at Hydro Quebec). The model has been used to study advanced physics scenarios for the Tokamak Physics Experiment (TPX), focusing on the use of off-axis current drive and reverse fast wave current drive (on-axis) to create profiles of the safety factor which exhibit shear reversal (inverted $q$-profile). This simulation model has also been used in conjunction with a 1 1/2-D transport code to investigate time-dependent access to these advanced tokamak operating modes. Similar studies have also been carried out for ITER. The possibility of achieving advanced physics regimes in the Alcator CMOD device through a combination of ICRF heating and off-axis LH current drive (for shear reversal) has been shown. Finally, preliminary work has been done to assess the feasibility of "low frequency" fast wave current drive in Alcator CMOD using an RF driver frequency (40 MHz) below the ion cyclotron frequency of the plasma, the same regime for fast wave current drive under study for ITER.

TECHNOLOGY AND ENGINEERING DIVISION

The Technology and Engineering Division is headed by Joseph Minervini and comprises 35 engineers, scientists and administrative and support staff. It supports graduate and undergraduate students in the Nuclear Engineering, Mechanical Engineering, Electrical Engineering and Computer Science, and Materials Science and Engineering departments.

This year the majority of the Division's work has focused on magnetics R&D for the International Thermonuclear Experimental Reactor (ITER), a quadripartite program (European Community, Japan, Russian Federation and United States) to design a prototype tokamak fusion reactor.

Bruce Montgomery leads the US Home Team Ex-Vessel Task area which includes magnetics, poloidal field performance scenarios, remote handling, and fueling. MIT plays the lead role in all magnetics work performed by the US Home team and oversees several large industrial R&D contracts for superconducting strand, special alloy tube products, and model coil fabrication. Major companies include Martin Marietta Astronautics Company and Westinghouse Science and Technology Center.

In-house research concentrates on conductor development, subscale testing, and magnet design and analysis. Continued development of Incoloy 908 conduit for the ITER conductors is a major activity, and is a collaboration between MIT and the International Nickel Company (INCO). Professor Ronald Ballinger of the Nuclear Engineering and Materials Science departments, developer of the Incoloy 908 alloy, has relocated his students, laboratory and test machines from the main campus to the PFC this year.

The Division also plays an important role in the Tokamak Physics Experiment (TPX), proposed as the next tokamak in the US national program. While the tokamak will be housed at the Princeton Plasma Physics Laboratory, the project design and management is national. Lawrence Livermore National Laboratory leads the magnetics development, and shares the task area management for the toroidal field and poloidal field coils with MIT. The conductor for the TPX will closely approximate that developed by the Division for the highly successful US Demonstration Poloidal Coil built under Division supervision in US industry and tested successfully at the Japanese Atomic Energy Research Institute's test facility.
Although the Superconducting Supercollider project was canceled in 1994, DOE made the decision to carry forward the design and construction of the GEM (gamma, electron, muon) detector model coil under the supervision of MIT. The coil uses a variant of the cable-in-conduit conductor technology developed by the Division. Production of the model coil will verify the design concepts and permit the construction of this type detector for another accelerator in the international program such as LHC, the Large Hadron Collider, planned for CERN. Had the GEM detector proceeded, the superconducting magnet system would have been the largest ever constructed at 18 m bore and 31 m total length.

In prior years the Division has played a major role in design of magnet systems for magnetically levitated high-speed ground transportation. Federal funding of this work has been very limited and is not expected to grow in the near-term future. Current work involves a study of the effects of maglev system magnetic fields on the rebar used in the concrete-supported guideway system. This is carried out for Professor Richard Thornton of the Electrical Engineering and Computer Science Department.

PLASMA TECHNOLOGY AND SYSTEMS DIVISION
The Plasma Technology and Systems Division, headed by Daniel R. Cohn, investigates plasma processing for environmental and industrial applications; develops new diagnostic technology for environmental and fusion applications; and investigates advanced fusion reactor systems designs and magnet concepts. Current research areas include arc plasma treatment of solid waste (Daniel R. Cohn, Paul P. Woskov, Charles H. Titus, and Jeffrey E. Surma); process diagnostic development (Paul P. Woskov and Daniel R. Cohn); cold plasma processing of gaseous waste (Richard M. Patrick and Daniel R. Cohn); millimeter wave and infrared diagnostic development (Paul P. Woskov); System Studies (Leslie Bromberg); high temperature superconducting magnet development (Leslie Bromberg); and fusion safety and environmental studies (Mujid S. Kazimi). Some highlights are:

Arc Plasma Furnace Treatment of Solid Waste
A pilot-scale arc plasma furnace to study treatment of simulated solid waste has undergone initial testing. The furnace has operated in a batch feed mode at average power levels of 100 to 200 kW and for short periods at a power level of 500 kW to glassify soil from the Idaho National Engineering Laboratory (INEL) site. The next goal is to demonstrate pouring of molten material with continuous feed. The furnace will then be used to study the vitrification of a variety of simulated waste materials for DOE environmental cleanup needs and other applications. With its special optimized design for pilot-scale study of waste treatment, the Mark 2 furnace could play an important role in thermal treatment technology development for environmental cleanup.

Process Diagnostics for Waste Treatment
New process diagnostics are being developed for the Mark 2 plasma furnace. These diagnostics also have applicability to other high temperature waste treatment, waste to energy, and energy-producing facilities. An active millimeter-wave pyrometer has been developed to measure furnace and material temperatures in a hostile environment. The device has been successfully tested in the Mark 2 furnace. The group has been notified that they will be receiving an R&D 100 Award for this diagnostic.

In addition, a microwave plasma analyzer for continuous monitoring of metals emissions has been successfully tested in a laboratory environment. Mark 2 furnace tests are planned for the last quarter of 1994. In addition to application to waste treatment in plasma furnaces, the capability for continuous monitoring of metals emissions could be applied to incinerators, waste to energy plants, and fossil fuel power plants.

Low Temperature Plasma Treatment of Gaseous Waste Streams
It has been demonstrated in the laboratory that low temperature plasmas generated by moderate energy (100-300 keV) electron beams can be used to selectively destroy dilute (1-1000 ppm) concentrations of volatile organic compounds (such as carbon tetrachloride and trichloroethylene) in air streams.

The high degree of selectivity results in a highly efficient relatively low cost process. This system is attractive to DOE for on-site treatment of solvents pumped out of the ground in remediation activities. Assembly and testing of a unit that will be field tested at the DOE Hanford facility is complete. The unit will be housed in a trailer which will be driven to Hanford. Initial field testing is planned for the fall of 1994.
Plasma Diagnostics Development
A gyrotron scattering system for alpha particle diagnostics is undergoing final testing on the TFTR tokamak at Princeton University. The diagnostic will provide information about the alpha particle density and distribution during deuterium-tritium operation. Work will also continue on implementation of the diagnostic on the JET tokamak in Abingdon, England.

WAVES AND BEAMS DIVISION
The Waves and Beams Division, headed by Richard Temkin, conducts research on novel sources of electromagnetic radiation and on the generation and acceleration of particle beams.

Gyrotron Research
The gyrotron, a novel source of microwave, millimeter wave and submillimeter wave radiation, uses a helical electron beam in a high magnetic field to generate radiation by stimulated emission at the electron cyclotron frequency. A gyrotron is currently under development for electron cyclotron resonance heating of the ITER plasma. Gyrotrons are also under development for high frequency radar. These applications require tubes operating at frequencies in the range 100-300 GHz at steady-state power levels approaching 1 MW. The gyrotron research group is led by Ken Kreischer.

Research has concentrated on the physics issues which affect efficiency of operation of high power, high frequency gyrotrons. Efficiency is a critical issue because it determines the recirculating power needed to sustain a practical fusion reactor and also greatly impacts the reliability and cost of plasma heating systems. A series of experiments has begun on a 110 GHz gyrotron which contains an internal mode converter. The converter transforms the high order waveguide mode created in the gyrotron cavity, the $TE_{22,6}$ mode, into a Gaussian beam in free space. A mode converter with an efficiency in excess of 95% was tested. A theoretical effort in collaboration with the University of Maryland has been conducted to explain the observed modes and efficiencies.

A program to demonstrate a high power, high frequency gyrotron suitable for application to ITER has begun and a prototype experiment at M.I.T. is under construction. The objective is to demonstrate a 1 MW, 170 GHz gyrotron with an efficiency of at least 35%. This work, led by MIT, will be carried out in collaboration with Varian, General Atomics, the University of Wisconsin, the University of Maryland and Lawrence Livermore National Laboratory.

The development of an industrial version of the prototype gyrotron with an output power of 1 MW, CW at 110 GHz has been initiated at Varian Associates in Palo Alto. The first gyrotron in this program was built and started test at Varian in March, 1994. The next tests are scheduled for September, 1994.

Relativistic Beam Physics Research
The Relativistic Beam Physics Group, led by Bruce Danly, investigates the generation of high voltage electron beams and their application to high power microwave generation. Research programs include investigations of the cyclotron autoresonance maser (CARM), the free electron laser (FEL), the relativistic klystron and the induction linear accelerator (ILAC).

The CARM is a novel, high power microwave source which is a promising candidate for high power generation at millimeter wavelengths. A CARM amplifier experiment at 17 GHz has been built using the electron beam from the SNOMAD II induction linear accelerator. The electron beam was operated at high repetition rate at 350 kV and 300 A in 20 ns pulses. The best results were obtained in gyrotron modes due to a reduced electron beam quality. Very good agreement has recently been obtained on the comparison of these results with theory.

An experiment has been carried out on a high power, 17 GHz klystron in collaboration with Haimson Research Corp. of Palo Alto, CA. The klystron electron gun was previously built for MIT and the klystron cavities were built by Haimson Research. The klystron demonstrated record power levels of up to 15 MW in 1 µs pulsed operation using a 500 kV, 120 A beam. An efficiency as high as 40% was achieved. Work is continuing to optimize klystron performance and apply it to high gradient acceleration experiments.
High Gradient Accelerator Research
The High Gradient Accelerator Experiments Group led by Shien Chi Chen is preparing a novel, 17 GHz microwave driven, photocathode electron injector. This device, sometimes called an RF gun, can generate a 2 ps beam of 2-3 MeV, 50-500 A electrons at high repetition rate. A 5 MW, 17 GHz source will drive the electron gun whose beam could be directly applied to microwave generation experiments or it could be used as an injector into a 17 GHz, high gradient accelerator.

The RF gun experiment has been operated with a short pulse (10 to 20 ns) source at power levels to about 5 MW at 17 GHz. This source is the third harmonic gyrotron amplifier using the induction accelerator. The power coupled into the electron gun was monitored using the forward and reflected microwave power. A stored field equivalent to an accelerating gradient as high as 50 MeV/m was estimated. Further work on this RF gun will be conducted with the 17 GHz klystron described above. Work is also progressing on generating the required laser pulse for the photocathode. This pulse must be timed to an accuracy of 1 ps in order to coincide with the 17 GHz accelerator field at a phase accurate to within 6 degrees.

Theoretical Research
The Intense Beam Theoretical Research Group led by Jonathan Wurtele has contributed significantly to the understanding of coherent radiation generation and particle acceleration. Topics covered include coherent radiation sources (CARM, FEL, gyrotron, relativistic klystron, relativistic TWT), beam-beam interactions, cyclotron resonance accelerators, two-beam accelerators, photocathode design, and other topics. Multimode codes have successfully predicted new phenomena in both the cyclotron autoresonance maser and free electron laser amplifier.

Theoretical research is underway on topics including the laser hose instability and frequency shifting in free-electron lasers. The laser hose instability is very important in the proposed application of very high peak power lasers to acceleration of electron beams to TeV energies in a plasma. Frequency shifting in free-electron laser oscillators and amplifiers has been investigated theoretically and numerically. The analysis includes frequency shifts from the resonant FEL interaction and the nonresonant beam dielectric. Expressions for the frequency shift in a microwave amplifier with time dependent beam energy and current were derived and found to be in good agreement with experiments.

RELATIVISTIC ELECTRONICS DIVISION
The Relativistic Electronics Division, led by Professor George Bekefi, carries out research on the generation of coherent electromagnetic radiation, using intense relativistic electron beams. This group studies experimentally and theoretically the basic physics characteristics of the free electron laser, the cyclotron maser and the relativistic klystron. Collaborative efforts include one with the Brookhaven National Laboratory where the MIT microwiggler has been installed for the purpose of generating coherent radiation at a wavelength of ~ 5000 Å and another with CERN/CLIC in which the Reversed Field FEL is being used to power the High Gradient Accelerating (HGA) structure designed and built at CERN and brought to MIT. A successful outcome of these experiments could lead to the realization of the next generation of colliders for particle physics.

AFFIRMATIVE ACTION
The Plasma Fusion Center is committed to increasing the number of women and minorities at those levels of the work force where there is significant under representation. Success in meeting this objective is dependent on the pool of applicants available at each level. For example, 90% of both the SRS administrative and support staff are women, while 27.5% of both support and service staff are African Americans. In these categories, search procedures using both internal and external resources have turned up an excellent supply of highly qualified candidates. On the other hand, at the SRS technical level, success is more modest: approximately 2.1% of SRS technical staff are women, while 10.3% are other minorities, most of whom are Asian Americans. A strong program is underway to enlarge the reservoir of qualified underrepresented applicants in the near term by more intensive dissemination of job postings to organizations specifically concerned with opportunities for women and other minorities and, in the long term, with a substantial K-12 and undergraduate outreach effort which encourages women and other minorities to pursue careers as scientists and engineers.
APPOINTMENTS AND PROMOTIONS
During the past year, there have been several important appointments and promotions in Plasma Fusion Center program areas:

Appointments include: Stephen Evans (Bowling Green State University) appointed Network Manager in the Fiscal Office; Paul Falkos (MIT, Spectroscopy Lab) appointed Research Staff Engineer; Gertraud Gillen (MIT, Physics) appointed Assistant Fiscal Officer in the Fiscal Office; Kathleen LaPier (MIT, Plasma Fusion Center) appointed Fiscal Officer-Temporary in the Fiscal Office; Chikang Li (MIT, Nuclear Engineering) appointed Postdoctoral Research Staff in the Physics Research Division; David Rhee (MIT, Nuclear Engineering) appointed Postdoctoral Research Staff in the Plasma Technology and Systems Division; David Ruble (MIT, Lab for Computer Science) appointed Assistant Fiscal Officer in the Fiscal Office; Matthew Schuetze (MIT, Nuclear Engineering) appointed Engineer-Temporary; Ali Shajii (MIT, Nuclear Engineering) appointed Postdoctoral Research Staff in the Fusion Technology and Engineering Division; and Katherine Ware (MIT, Earth Atmospheric and Planetary Sciences) appointed Sr. Fiscal Officer in the Fiscal Office.

Internal promotions in the Plasma Fusion Center during the past year include: Alberta Dawson, promoted to Assistant Head, Fusion Technology and Engineering Division, Matthew Fulton, promoted to Operations and Safety Coordinator in the Technical Operations and Planning and the Environmental Health and Safety Offices; and Robert Randall, promoted to Engineer in the Fusion Technology and Engineering Division.

During the past year, there was one Institute research promotion in the Plasma Fusion Center: Dr. D. Bruce Montgomery, promoted to PFC Interim Director.

The Plasma Fusion Center has also hosted 75 Visiting Scientists, Engineers and Scholars during the past year.

GRADUATE DEGREES
During the past year, the following students graduated with theses in plasma fusion and related areas: Dexter Beals, M.S., Electrical Engineering and Computer Science; Kai-Pak Chan, Ph.D., Electrical Engineering and Computer Science; Ronson Yiu-Yuen Chu, Ph.D., in Physics; Mitchell Crosswaite, Ph.D., Nuclear Engineering; Robert Gormley, Ph.D., Nuclear Engineering; Thomas Hsu, Ph.D., Nuclear Engineering; Mathias Koch, Ph.D., Nuclear Engineering; Chikang Li, Ph.D., Nuclear Engineering; David Rhee, Ph.D., Nuclear Engineering; Matthew Schuetze, M.S., Nuclear Engineering; Ali Shajii, Ph.D., Nuclear Engineering; Chi-Wa Tsui, Ph.D., Nuclear Engineering; John Urbahn, Ph.D., Nuclear Engineering; and Xia-Tong Yu, Ph.D., Physics.

We take this opportunity to wish these graduates success in their future professional endeavors.

D. BRUCE MONTGOMERY
INTERIM DIRECTOR
MIT PLASMA FUSION CENTER
INTRODUCTION

The Research Laboratory of Electronics (RLE), the Institute's oldest interdisciplinary research laboratory, was founded in 1946 as the natural evolution of the wartime MIT Radiation Laboratory. Initially, RLE was formed to bring together interests in physics and electrical engineering to work on problems in electromagnetic radiation, circuits, and specialized vacuum tubes. Over the years, RLE's research interests have branched out in many directions, and in fact, several of these interests have precipitated the formation of additional laboratories. Research within RLE is conducted by approximately 55 faculty members who are affiliated with the Departments of Electrical Engineering and Computer Science, Physics, Chemistry, Materials Science and Engineering, Aeronautics and Astronautics, and Linguistics. During the past year, approximately 200 graduate students and 75 undergraduates have worked on research projects within RLE. Major support is derived from the Joint Services Electronics Program (JSEP) of the Army, Navy, and Air Force; other Defense Department agencies; the Department of Energy (DOE); the National Science Foundation (NSF); the National Institutes of Health (NIH); and the National Aeronautics and Space Administration (NASA). In addition, many research projects are funded through industry and private foundations. Although RLE has a very heterogeneous character, its organization is composed of two major thrusts and several smaller focus areas. One major thrust is centered on electronics and optics, and the other is centered on language, speech, and hearing. Each of the smaller focus areas often has substantial overlap with other research in RLE.

In the following remarks, several research highlights from 1993 are briefly mentioned. The interested reader can obtain further information from RLE Progress Report No. 136, which describes research activities during calendar year 1993.

ELECTRONICS AND OPTICS

Materials and Fabrication

Professor Clifton Fonstad has developed a theory that successfully explains for the first time the polarization selection rules followed by quantum well intersubband optical transitions. This result provides the theoretical foundations to significantly simplify quantum well infrared photodetectors that were previously proposed. Professor Jesus del Alamo has shown that impact ionization plays an important role, even under moderate biases, in InAlAs/InGaAs heterostructure field-effect transistors. He has used this new understanding to predict terminal currents for any bias condition. In this way, accurate models for phenomena that depend on impact ionizations (such as noise, breakdown voltage, and output conductance) are now available. Professor Leslie Kolodziejski, who is concentrating on epitaxial growth of III-V and II-VI compound semiconductors, has achieved a new understanding of the p-type doping of ZnSe grown by gas-source molecular epitaxy. The source of hydrogen, which appears to hinder the electrical activation of acceptors, has been determined. This will have substantial impact on the further understanding of current limitations in the p-type doping by metallorganic chemical vapor deposition and gaseous source epitaxy technologies.

Quantum-Effect Devices

Professor Raymond Ashoori continues to build up laboratory facilities needed to study single-electron capacitance spectroscopy, which is leading to a detailed understanding of artificial atoms. While pursuing a deeper understanding of single-electron transistors, Professor Marc Kastner has used the single-electron conductance peak to measure the chemical potential of the electron droplet in the transistor. This has been shown to agree with recent theory. In collaboration with Professor Dimitri Antoniadis, Professor Henry Smith has fabricated the highest performance tenth-micron MOSFET transistors of any group in the world by using the x-ray lithography capabilities in his laboratory. Single-electron transistors, in which the size of the Coulomb island can be controlled by an external voltage, have been successfully fabricated. First-order Bragg diffraction gratings in optical waveguides have been achieved that use a combination of spatial-phase-locked electron-beam and x-ray lithographies.

Optics and Devices

Professors Hermann Haus and Erich Ippen have been perfecting fiber ring lasers as optical pulse sources. They have succeeded in harmonically modelocking a fiber ring laser that is self-stabilized at one gigahertz. A particularly intriguing result is the development of a fiber ring all-optical memory that has retained an injected pattern for a half-hour. The travel distance with no distortion of these patterns was $10^{10}$ kilometers, which set a new record. For the first time, Professor Qing Hu has observed quantum oscillation of far-infrared, radiation-induced thermal power signals in an electron waveguide device. He has also succeeded in fabricating millimeter-wave superconducting receivers by using micromachining techniques.
Surfaces and Interfaces

The ability to calculate the conductivities of electronic systems has been further developed by Professor Nihat Berker; taking into account the effects of surfaces, finite sizes, impurities, and thermal fluctuations. These calculations are directly applicable to mesoscopic systems and may also be applicable to superconductivity.

Circuits and Systems

Professor John Wyatt has found a clever way to create a brightness-adaptive charge-coupled device imager that provides high sensitivity in dark areas and reduced sensitivity in bright areas. He has also developed a new method to surgically mount a silicon retinal implant chip on an experimental rabbit retina. Sensitive cortical monitoring permits the study of the system’s behavior. Very fast and efficient tools for capacitance and inductance extraction have been developed by Professor Jacob White. These are now being used at over 200 sites, including three companies. Using newly developed algorithms, he has extended the capability of the SPICE circuit simulation program by efficiently incorporating frequency-dependent elements found in transmission lines and electronic packages. Professor Srinivas Devadas has achieved new algorithmic and theoretical advances for digital system synthesis, where the goal is to reduce power dissipation. One technique, called precomputation, checks to see if the result can be computed by means simpler than the normal algorithm. When this result is found, significantly less dissipative logic circuits can be used, rather than the more conventional logical constructs.

LANGUAGE, SPEECH, AND HEARING

Speech Communication

Professor Kenneth Stevens has developed new procedures to assess the speech production capabilities of dysarthric speakers. Based on these assessments, vocabularies of words that can be used by these individuals for spoken communication with computers have been devised. In addition, a set of descriptors for the acoustic analysis of female speakers has been obtained. In the study of speech articulator motor control, Dr. Joseph Perkell has achieved new results, which have led him to speculate that speech motor programming is based, in part, on acoustic goals rather than being dominated by the physical shape of the vocal tract. He is also studying changes in speech when postlingually deafened adults start to use cochlear implants. Of particular significance is the finding that supports a model in which hearing is needed absolutely to acquire speech. But, once speech has been acquired, hearing is used more to maintain overlearned phonemic settings, and to make relatively rapid adjustments in postural parameters such as rate, pitch, and loudness, in response to changing environmental conditions and listener needs.

Sensory Communication

Professor Louis Braida has accurately simulated the effects of sensorineural hearing loss. This has led to new techniques for the functional simulation of hearing impairment that can be useful in communicating with individuals who suffer from this type of hearing loss. Dr. Kenneth Salisbury has focused on sensor-guided grasping and has developed the MIT WAM robot arm that will demonstrate how it can grasp a thrown ball with the aid of a new active vision system and a new wrist hand. He has also collaborated with Dr. Mandayam Srinivasan on the development of touch perception algorithms. These will enable robots to deduce contact, texture, constraint, and motion. A new haptic interface was developed that exerts precisely controlled force vectors on a user's fingertips, enabling mechanical interaction with virtual objects in a way that facilitates the perception of touch, shape, texture, and motion.

Auditory Physiology

Professor Thomas Weiss and Dr. Dennis Freeman completed the implementation and testing of an automated microscopy system to measure sound-induced nanometer displacements of cochlear structures. The system automatically obtains stroboscopically illuminated images of the cochlear at a sequence of different depths of focus and at different phases of the sinusoidal sound stimulus. From these three-dimensional images, the motion of every visible structure can be computed. The use of this system will provide experimental measurements of cochlear mechanics at levels that previously were addressed only theoretically. Professor Donald Eddington continues to study cochlear implants, where he has shown that postlingually deafened individuals can communicate well by using the implant, especially when it is complemented by lipreading. He has also extended the design of anatomically and physiologically based models to predict physiological and psychophysical data derived from human and animal subjects. This has provided a rational basis for the design of new implant systems that will result in improved speech recognition for the deaf. Dr. John Rosowski has conveyed to otologic surgeons guidelines derived from the understanding of the relationship between structure and function of the external and middle ear which will be used in middle-ear reconstruction.
FOCUS AREAS

Atomic, Molecular, and Optical Physics

Professor Shaoul Ezekiel has developed a novel scheme for high-density storage, based on a five-dimensional, holographic optical method. He has also developed a fiberoptic-based system for quench detection that is immune to electromagnetic interference in superconducting magnets that will be useful in the next generation of magnetic confinement fusion machines. The single-ion cyclotron resonance mass spectrometer, developed by Professor David Pritchard, has been used to determine the atomic mass of about ten elements with more than an order of magnitude in improved accuracy over the previous state of the art. These results will provide an essential ingredient in a new plan to replace the current standard kilogram that is made of platinum by a precisely grown silicon crystal. Additionally, these techniques have allowed gamma rays to be effectively weighed. Professor Wolfgang Ketterle has achieved evaporative cooling for the first time with laser-cooled atoms. This technique should lead to temperatures well below those obtained with optical methods.

Plasma Physics

The generation of coherent electromagnetic radiation using intense relativistic electron beams is the research focus of Professor George Bekefi. He has installed a microwiggler at Brookhaven National Laboratory in order to generate coherent radiation at a wavelength of approximately 5,000 Å. The use of these techniques could lead to the next generation of colliders for particle physics. Professor Abraham Bers has achieved a theoretical explanation of the observed enhancement of noninductive current drive in the European JET tokamak. This was accomplished by the synergism between lower-hybrid current drive and ion-cyclotron heating using fast Alfven waves. Stimulated by recent experiments at the Princeton tokamak facility, a new theoretical analysis for the mode conversion of fast alpha waves to ion-Bernstein waves has been developed. A phenomenon called the isotopic effect, previously described by Professor Bruno Coppi, has been confirmed in recent experiments. This effect explains an increase of the energy confinement properties when changing the plasma composition in a tokamak from hydrogen to deuterium or to deuterium-tritium. This is the opposite of what could be predicted from the theory of two species of plasmas, such as electrons and deuterons.

Radio Astronomy

Professor Bernard Burke is carrying out a large study using the Very Large Array facility of the National Radio Astronomy Observatory in order to search for the morphological structures characteristic of gravitational lensing. This phenomenon involves radio signals from distant galaxies that are distorted by foreground galaxies, resulting in the production of multiple images. Professor Jacqueline has also been studying gravitational lenses and has concentrated on the variable images emanating from the first Einstein ring gravitational lens that was discovered. A well-constrained model for this gravitational lens makes it a particularly attractive candidate for a Hubble constant measurement. Professor David Staelin has introduced improved signal processing techniques in order to interpret passive microwave remote sensing data from satellites. He has developed a new nonlinear transform technique to efficiently compress such data. Dr. Philip Rosenkranz has used passive microwave radiometric measurements of the earth and its atmosphere in order to calculate atmospheric weighting functions. These will be applied in retrieving atmospheric temperature profiles from the measurements of future generations of weather satellites.

Digital Signal Processing

Professor Alan Oppenheim continues to explore chaotic signals and their use in signal masking. In addition, he has developed new techniques for signal enhancement and active noise cancellation that may be potentially useful in a noise-cancelling headset. Professor Gregory Wornell has developed several new algorithms to combat fading and interference in digital wireless systems.

Advanced Television and Signal Processing

Professor Jae Lim has developed new television algorithms that have been incorporated by the Grand Alliance, a consortium that includes several companies and MIT. The prototype system developed by the alliance is scheduled to be tested at the end of 1994 by the Federal Communications Commission. Professor William Schreiber has been concentrating on the efficient use of the over-the-air spectrum by using spread-spectrum and orthogonal frequency-division multiplexing. This system features higher resistance to analog channel impairments and self-optimization at each receiver depending on signal quality and receiver performance, and provides extended coverage as compared with conventional systems.

Electromagnetics

Professor Jin Au Kong has applied electromagnetic wave theory to studies that include remote sensing, electromagnetic interference, integrated circuit interconnects, and the optical frequency assignment of instrument landing systems.
Optical Communications

Professor Jeffrey Shapiro has shown that classical field propagation underlies the phenomena seen in parametric interactions in second-order nonlinear crystals, such as quadrature noise squeezing, twin-beam generation, and nonclassical fourth-order interference. Quantum optics enters only through the observation of these phenomena via fourth-order interference. Dr. Franco Wong is developing ultraprecise methods to measure absolute optical frequencies relative to the cesium atomic clock. Through the use of doubly resonant, optical parametric oscillators, he is developing an optical frequency counter that is capable of measuring any optical frequency by employing only two calibration lasers and a parallel network of these oscillators.

Computer-Aided Fabrication

Professor Donald Troxel has developed a microsystems factory representation that is a key part of a methodology for the design, redesign, dynamic reconfiguration, and operation of production systems. Although this system was initially developed for integrated circuit manufacturing, it can also be applied to all types of manufacturing.

Electronics for Biological Analysis

Drs. Daniel Ehrlich, Mark Hollis, and Dennis Rathman have continued their work on a new technology for DNA sequence determination. Using these new techniques, working prototypes of microelectronic chips called genosensors were developed. The complexity of these new devices is sufficient to enable the diagnosis of genetic diseases such as cystic fibrosis. It is hoped that these genosensors will form the basis for new genetic testing methodology in the future.

AFFIRMATIVE ACTION

RLE has worked and will continue working to increase the number of women and minorities in career positions in the laboratory, in the context of the limited pool of qualified technical applicants and the unique qualifications of the RLE's sponsored research staff. Specific measures will include: (1) maintaining our high standards for recruitment procedures that include sending job postings to minority colleges and organizations; (2) working closely with the RLE faculty/staff supervisor at the beginning of each search to identify ways of recruiting minority and women candidates for the new position; and (3) being committed to finding new techniques to more effectively identify women and minority candidates and to being more open to suggestions in this area. During the past year, due to limited turnover in RLE's research staff, success in affirmative action for research and support staff personnel have been limited. Of the two research staff appointments made this year, one was made to a woman.

JONATHAN ALLEN
Sea Grant College Program

The MIT Sea Grant College Program provides funds for research, education, and technology transfer directed toward wise utilization of marine resources. MIT has been a leading participant in the national program since 1969. In 1976 the Institute was designated a Sea Grant College Program, the only private university to receive this recognition. Sea Grant College status offers the potential for greater funding and confers a responsibility to work with marine researchers throughout the Commonwealth.

Funds are distributed among the 29 Sea Grant Programs in a competing grant process by the National Oceanic and Atmospheric Administration through its National Office of Sea Grant. Each program is required to match every two dollars of its federal grant with one from non-federal sources. Congress established this matching provision to ensure that Sea Grant universities would be responsive to public and industry needs. Sea Grant provides funds explicitly for technology transfer through its mandate for advisory services and education as well as research.

In FY 1994 the National Office of Sea Grant awarded MIT $1.87 million. MIT, industry partners, the Commonwealth, the Massachusetts Water Resources Authority (MWRA) provided nearly $1.6 million in matching funds. In addition, MIT Sea Grant also received more than $1.7 million in related research from other federal and non-federal agencies. In all, these funds provided partial support for about 27 faculty members, five post-doctoral fellows and 46 students from seven departments, including Civil and Environmental, Chemical, Ocean and Mechanical Engineering (as well as partial support for faculty and students at UMass/Boston, Brandeis University, Boston College, Boston University, Harvard University, and Northeastern University).

RESEARCH
Research at MIT Sea Grant is guided by both the unique intellectual resources of Massachusetts universities and the needs of the marine community. This research is currently focused in five theme areas: autonomous mobile instrumentation platforms, marine biotechnology, ocean and coastal processes, ocean engineering, and technology development and management for ocean uses. In addition to the five theme areas, Automation in the Manufacture of Marine Systems continued as one of Sea Grant's strongest activities, although it is now supported entirely from sources outside Sea Grant. A recent accomplishment includes the development of an integrated theory for the representation and interrogation of objects bounded by interval curved surfaces in a computer environment. This is at the core of computer-aided engineering of complex mechanical systems encountered in heavy industries.

Work on underwater systems is carried out under Sea Grant's research theme area Autonomous Mobile Instrumentation Platforms. The project "Autonomous Underwater Vehicles," (AUVs) encompasses a broad program aimed at making autonomous underwater systems useful tools for coastal and oceanic research and/or monitoring programs. The investigations focus on intelligent control, navigation and application of autonomous vehicles to specific scientific missions. The program has been sponsored by MIT; MIT Sea Grant; ARPA; Charles Stark Draper Laboratories; Office of Naval Research, the National Science Foundation; French Institute for Research and Sea Exploration; and the Department of the Navy.

Unique in its status as a research laboratory within a Sea Grant program, the MIT Sea Grant Underwater Vehicles Laboratory is the center of much of MIT Sea Grant's AUV research and development. A major event for the Underwater Vehicles Laboratory this year was deployment and recovery of the AUV Odyssey II under ice in New Hampshire and in the Arctic, with partial ONR funding and in conjunction with other MIT acoustic research projects. The Office of Sea Grant awarded us competitive supplementary funding for a two-year program to provide a quick response to geological events along the Juan de Fuca Ridge, utilizing Odyssey II. The first mission is scheduled for July and August 1994. Professor Henrik Schmidt of the Department of Ocean Engineering oversees this research area as associate director for research, and James G. Bellingham directs the AUV Lab with support from Thomas G. Consi. The laboratory supports six postdoctoral fellows and three graduate students.

Sea Grant's research objective in Marine Biotechnology is the advancement of technology that can contribute effectively to better use of the biological resources of ocean and coastal ecosystems. Recent and ongoing research has focused on the application of biotechnology to drug delivery and to reproductive barriers in aquaculture-raised fish, understanding the relationship between vanadium and tunichrome in sea squirts, and biochemical markers for pollution damage in fisheries. In addition, Professor Ralph Mitchell, of Harvard University, continues to study zebra mussels, a non-indigenous, invading species threatening inland water supplies and ecosystems.

Interdisciplinary Sea Grant investigations of Ocean and Coastal Processes seek to describe and model currents in order to estimate the fate of sediments and chemical compounds in near-shore environments. Projects during the past year included studying the effect of seawalls on coastal sediment transport and understanding the effect of trace metals on algae. Another major project in this theme area focuses on pollution in Boston Harbor and Massachusetts Bay. This project has strong
collateral support from the National Science Foundation (NSF), the Environmental Protection Agency, and the Massachusetts Water Resources Authority (MWRA). Dr. Eric Adams of Civil Engineering oversees Ocean and Coastal Processes.

In a project in Sea Grant's Ocean Engineering theme area, and complimenting Sea Grant's Autonomous Underwater Vehicles research (above), Sea Grant-supported researchers are designing novel, efficient propulsors for unmanned underwater vehicles based on analysis of jets and vortices produced by fast-swimming fish. Research under Ocean Engineering includes developing technology for the difficult task of measuring and analyzing marine pollutants in situ. The behavior of suction caisson foundations is also the subject of continuing research.

Sea Grant's Technology Development and Management theme area has traditionally been a source of funds for investigating new programs that may develop into future theme areas or show particular promise in solving important marine-related problems. The focused research activities in Coastal Engineering and in Autonomous Mobile Instrumentation Platforms started as projects in Technology Development. These projects have as their goal the addressing of significant national and international programs. We seek in this area, especially, to integrate industry partners into the research programs.

EDUCATION
Sea Grant is committed to providing learning opportunities to university students, professionals, and the public. Support for graduate students is included in almost every research project. In addition, the program continues to provide major support for marine-related Undergraduate Research Opportunities Program (UROP) projects. The National Science Foundation and the MIT Chair for Teaching Innovation continued to support an investigation of collaboration of undergraduates in the interdisciplinary design construction and testing of an AUV.

Sea Grant UROP directly provides $25,000. Support from other departments (primarily Ocean Engineering) and $35,000 from the National Science Foundation raise the total funding to $70,000. Twenty-two UROPs were supported for Summer 1993, nine for the Fall 1993 term, six for IAP/Spring 1994 and 11 for Summer 1994. Undergraduates from Aeronautics and Astronautics, Civil and Environmental Engineering, Ocean Engineering, Mechanical Engineering, Chemical Engineering, and Electrical Engineering and Computer Science were represented, as well as students from Physics, Economics, and Mathematics.

The Dean A. Horn Award was established in 1982 to honor the contributions of a former Sea Grant director. The award is given to the marine-related UROP project that best reflects Mr. Horn's high regard for significant innovative marine research projects carried out with competence and reported with clarity. In September 1993, the award was given to Civil and Environmental Engineering student Amy B. Chan for her summer UROP at the MWRA, estimating contaminant loading in Boston Harbor and Massachusetts Bay.

A computer display installed at the Charlestown facility was successful. A new, two-part exhibit designed expressly for the New England Aquarium was installed and is receiving enthusiastic support. It uses animation, sound and text in an interactive computer-based stations. The first explains the Boston metropolitan sewage system, the changes it is going through, and the Boston Harbor cleanup. The second teaches what people can do to protect the Harbor. In addition, a computer program covering the same subject, but in greater depth, continues to be widely distributed to schools, where teachers integrate it into the curriculum. This program is in use by outreach groups on the MIT campus.

MIT Sea Grant's fifth John A. Knauss Sea Grant Policy Fellow is Shane Merz, a graduate student in Ocean Engineering. Merz is participating actively in the office of Senator Akaka of Hawaii.

PROGRAM MANAGEMENT
The program director is Chryssostomos Chryssostomidis, professor in the Department of Ocean Engineering. Associate directors for research are Henrik Schmidt, associate professor in the Department of Ocean Engineering; E. Eric Adams, senior scientist in the Department of Civil Engineering; and Marcia K. McNutt, professor in the Department of Earth, Atmospheric and Planetary Sciences. Norman Doelling, assistant director, oversees the operation of Sea Grant Advisory Services and Education.

MIT Sea Grant administers the Doherty Professorship, endowed by the Henry L. and Grace Doherty Foundation in 1973, for junior faculty at the Institute. In the Spring of 1994, Frank Z. Feng, assistant professor of Mechanical Engineering, was awarded the two-year chair for his proposal to study wave-wave interaction due to nonlinear resonance and to numerically simulate the effects of surface films on wave motions. This research should provide a theoretical basis for detecting oil spills by remote sensing. In addition, the award of the first Doherty Foundation-funded professorship in Ocean Science and Engineering to Sea Grant Director Chryssostomidis is extremely helpful in furthering our research agenda.
TECHNOLOGY TRANSFER

Sea Grant's legislation explicitly provides funds for technology transfer as an integral part of the program. Additionally, the technology transfer projects are designed to bring current user needs to the attention of MIT Sea Grant researchers. Thus, technology exchange may be a better description of our efforts.

The MIT Sea Grant Marine Industry Collegium promotes the active transfer of marine research and technology through the sponsorship of workshops, distribution of publications and research reports, and direct interaction with members. Since 1975, the Collegium has provided member organizations with the opportunity to attend several technical workshops and symposia per year. The Collegium program collaborates with Draper Laboratories and with other campus organizations in sponsoring symposia and workshops. During the past year, Collegium workshops included Marine Biotechnology in the Northeast Region: Current and Future Research Initiatives and Commercialization of Autonomous Underwater Vehicles.

MIT Sea Grant's Center for Fisheries Engineering is recognized as an important national resource for technical studies of fishing gear and vessel design. Using tow tanks at MIT and at the David Taylor Model Basin in Bethesda, Md., the Center tests scale-model trawl systems and conducts courses for fishermen. Industry turns to the Center for testing and evaluation of new trawl net designs and innovative aquaculture pen systems. The Center also assists the local fishing industry with technological problems in gear design, selectivity, and marine mammal interactions. In addition, fisheries engineer Clifford Goudey has been instrumental in developing technology to help remove noxious algae contaminating North Shore beaches.

The Massachusetts Marine Liaison Service (MMLS) works with state and federal agencies and the public, to identify and address local and regional needs in fisheries and coastal zone management. Marine advisory agent Madeleine Hall-Arber is working with the New England Fishery Management Council to provide a social impact assessment of new fisheries regulations. Her study of the anticipated impacts of the regulations on fishing communities has been widely read in NOAA and in Congressional staff offices. MMLS is also working with the Metropolitan District Commission to educate boaters and industrial fresh-water users to minimize the impact of zebra mussels. Hall-Arber serves on the advisory board to the Massachusetts Coastal Zone Management Program, the New England Marine Advisory Council and the Women's Fisheries Network. Public education efforts continue through exhibits, participation in conferences and festivals, articles in Commercial Fisheries News, and publication of the Citizen's Guide to Sources for Marine and Coastal Information.

The Sea Grant Communications/Information Service produces outreach materials a wide variety of consumers: from technology professionals to harbormasters. In 1993-1994 Communications/Information Service published 23 works, including a directory of marine-related research at MIT, technical reports and brochures. Communications continues to write and publish a quarterly newsletter with a circulation of 2,000 (Quarterly Report), and continues its involvement in Nor'easter, a regional Sea Grant magazine (circ. 12,000). Communications also wrote and produced the interactive computer programs referred to above. Working with the press and with the MIT News Office resulted in stories in Scientific American, Technology Review, The Boston Globe, The London Times and Weekly Reader, WCVB-TV, and other general-interest media, as well as national and international trade journals. The service also installed or updated exhibits about Sea Grant and MIT activities. These included exhibits at ILP's research director's conference and at the Boston National Historic Park's Charlestown Navy Yard.

During the year, MIT Sea Grant continued to develop support for faculty and students in public service through application of new technology to marine and coastal problems in Massachusetts. Projects involved helping solve problems with noxious algae on the North Shore, studying forces on moorings, studying the effects of marine dredging, experimental use of chitin as a replacement for alum in water pre-treatment and comparing methods of non-traditional sewage treatment. This project provides additional support for faculty and their students.
Technology and Development Program

INTRODUCTION

The Technology and Development Program’s (TDP) primary mission is to provide a focus at MIT for research and education related to the role of science and technology in the socioeconomic growth of developing countries. Its specific objectives are to:

- Promote an awareness of the relationship between science, technology, and development on the part of faculty and students at MIT;
- Provide a focal point for the activities of faculty, students, and visiting scholars interested in the field of technology and development;
- Assist the faculty, students, and staff of collaborating institutions in other countries to develop research and academic interests consistent with their national needs;
- Serve as a contact for interested organizations outside MIT (government, academic, private sector) to access the Institute’s resources and its knowledge of developing countries -- particularly of their socioeconomic and technological problems.

The TDP carries out these objectives through research, academic programs, and contacts with international and national organizations that have an interest in broad areas of technology and development. In order to fully utilize available resources, the TDP is structured to interact with other academic departments and research centers throughout MIT.

CURRENT RESEARCH PROGRAMS

In October 1990, TDP initiated a Collaborative Program on Science, Technology, and Development between MIT and the American University of Beirut. The program involves specific joint research projects which are relevant to the reconstruction and redevelopment of both physical and institutional resources in Lebanon. Now in its fourth year, the program has completed four projects: Wastewater Treatment (Civil and Environmental Engineering); Municipal Waste Disposal (Mechanical Engineering); Lebanese Power System Reconstruction (Electrical Engineering); and Residential Sector Rebuilding (Urban Studies and Planning). Four other projects are currently underway: Passenger Transportation Options (Center for Transportation Studies); Human Resources Development (Political Science) Multi-Media Technology (Center for Educational Computing Initiatives); and Geographic Information Systems (Urban Studies and Planning). Program participation has included 12 faculty/research staff and 10 graduate students from MIT; and 9 visiting faculty and 15 visiting scholar graduate students from AUB. Eight additional AUB faculty members have visited MIT on three month faculty development scholarships.

CURRENT EDUCATION INITIATIVES

The TDP-sponsored Middle East Program at MIT completed its eight year with 10-12 graduate students participating each semester. The program enables students with an interest in the Middle East to develop an expertise in the area in addition to their own academic fields of specialization. The program examines the processes of socio-economic change, technological development, political change, institutional development, capital flows, and business and investment patterns in the region. Three interdepartmental courses are offered by the program: Politics, Growth, and Development in the Middle East; Technology, Business and Public Policy in the Middle East; and Reconstruction. The Middle East Program is under the direction of Professor Nazli Choucri, TDP Associate Director, and involves faculty from the Department of Political Science, Department of Economics, the History Faculty, the Department of Urban Studies and Planning, the Sloan School of Management, the Department of Civil and Environmental Engineering, the Science, Technology and Society Program, and the Aga Khan Program in Islamic Architecture.

ORGANIZATION

The TDP Director is Professor Fred Moavenzadeh, George Macomber Professor of Construction Management in the Department of Civil and Environmental Engineering. Professor Nazli Choucri of the Department of Political Science is the Program's Associate Director and Chairman of the Policy Committee. Other Committee members are Professors Moavenzadeh and Jack R. Ruina of the Department of Electrical Engineering.

FRED MOAVENZADEH
As the following reports from the four administrative groupings of the Libraries indicate, the academic year 1993-1994 was replete with challenges and opportunities. The successful conclusion of the year was due in large measure to the continuing dedication and perseverance of the entire staff of the MIT Libraries. The substantial commitment of time to the implementation of a new library operating system created considerable pressure throughout the Libraries, but as has been true for all of the recent past, the staff rose to the occasion and the quality of service to the MIT community was maintained at its traditionally high level. The setback caused by the cancellation by Ameritech of the NOTIS Horizon project will certainly delay implementation but action is underway on a number of fronts aimed at identifying another system with a goal of full implementation in late fall of 1995. Great progress was also made in the delivery of electronic information on the campus, most notably in the use of Gophers, Mosaic, World Wide Web, and OCLC's FirstSearch.

The Director of Libraries represented the Institute in a number of national and international library and information ventures. One of these was the Association of American Universities' Association of Research Libraries project on research libraries in which President Charles Vest was a member of the steering committee. Other programs included the Sub-Saharan Africa Library Program of the American Association for the Advancement of Science which this year had sessions on strategic planning and on the use of CD-ROM technology. The MIT Libraries have been identified as the key supplier of documents for the African libraries involved. The Director continued as a member of the Commission on Global Environment Change Information Policy, as chair of the North American Group of the International Association of Technological University Libraries, and served as President of the Boston Library Consortium. Members of the Libraries' staff were extremely active in the BLC, especially in cooperative collection development, information technology, and the union list of serials project. The MIT Libraries have been identified as key participants in a new ARL program in Japanese scientific and technical information.

The number of professional and scholarly organizations in which members of the Libraries' staff were involved during the year covers a wide spectrum of disciplines and services. Among them were the Coalition for Networked Information, American Library Association, American Institute for Image Management, North American Serials Interest Group, Special Libraries Association, Art Libraries Society of North America, NELINET, Mass COPAR (Committee for the Preservation of Architectural Records), Association of College and Research Libraries, Music Library Association, Computer Professionals for Social Responsibility, Geological Information Society, American Society for Information Science, Boston Computer Society, Simmons College Graduate School of Library and Information Science (alumni association), Society of American Archivists, New England Archivists.

A number of administrative changes took place during the year including the transfer of management of Document Services (formerly the Microreproduction Laboratory) from the Associate Director for Administration to the Associate Director for Public Services. Subsequently, the Computerized Literature Search Service was made part of Document Services. Administration of the Humanities and Dewey Libraries was merged under a new head and associate head, and the position Librarian of the Sloan School of Management was created from an existing vacancy. The Systems Office was elevated to departmental status and its head became a member of Library Council.

In the Institute Archives and Special Collections, the investigations at the national level into the use of radioactive substances on human subjects required an extraordinary effort by the staff. The event emphasized the importance of a number of aspects of the work of the Archives: providing information to MIT administrators to support legal and administrative needs; providing information to outside users; gathering and preserving a historical record of MIT to support administrative and historical needs. This episode not only confirmed the soundness of past collecting activities but also provided an opportunity for future documentation planning. At the request of the Vice President and Dean for Research, the Institute Archivist surveyed the records and established a collecting plan with the Nuclear Reactor Laboratory and the Clinical Research Center, the two areas on campus where research on humans is still conducted.
Extensive use of archival and manuscript collections was made by individuals from within and outside MIT. Among the areas studied were the history of food technology teaching and research at MIT, establishment of institutes of science and technology, governmental science policy, cybernetics, supersonic air transport, neuroendocrinology, antiballistic missile technology, earthquake engineering, and physiology. The completion of the finding aid for the Harold Edgerton papers has encouraged researchers to begin using this rich resource.

The Rotch Library was again honored for architectural achievement through the award by the Boston Society of Architects of the Harleston Parker Medal as "the most beautiful new building in Boston in the last ten years."

**ADMINISTRATION**

**Finances and Accounting**

The Libraries again closed its books with some reserve funds available and was able to pay off the Institute loan that was used for the renovation of the technical services area, 14E-210. This will provide much needed financial flexibility for FY95 as pressure on the budget from serials inflation and the decline of the dollar against several foreign currencies continues.

Income from the sale of library cards was down 2% from FY93 due to the cancellation of three group membership plans. The number of individual cards rose by 9% partially offsetting this decline.

An important benefit resulted from the participation of Administrative Services personnel in the Horizon implementation. The network drops that were installed permit access to Comptroller's Accounting Office's new $SumMIT software. This client/server system will provide access to financial reports, a new telecommunications accounting system, and a new journal voucher system.

**Personnel**

Two national searches for librarian positions were completed during FY94; two other searches were canceled because of reorganizations within the Libraries. Another seven searches were initiated during the year and were still in progress as FY95 began. Two of these were for temporary, grant-funded positions: for a Japanese science and technology information specialist, and for an archival cataloger. Despite intensified efforts to recruit under-represented minority candidates, neither of the completed searches yielded such an appointment. There has, however, been a small but measurable increase in the number of minority applications and a concomitant increase in their representation in final pools.

Evaluations of all staff took place according to schedule. The requisite annual review for all beginning professional librarians was also conducted and promotion plans have been documented for each of them.

During the year, the Libraries eliminated production of a paper staff directory and went to an online version. It now resides on the staff Gopher. Maintenance of the list resides with Administrative Services. A process was developed that links Athena e-mail addresses with the staff list.

In the spring of 1994, the Libraries formalized the Internship Program that previously had been a pilot project. A recommendation to this effect was made by the Ad Hoc Committee on Staff Development. As of June 30, 1994, nine internships had been identified of which five had been filled. Evaluations will be conducted at the end of the summer.

During the summer of 1993, the Libraries again participated in the Cambridge Summer Teen Work Program. Two students were employed through this program and they worked in various areas of the Libraries providing support for stacking, shelf reading, barcoding, data input, and photocopying. One of them stayed on in the Director's Office during the academic year and both returned for the summer of 1994.
Staff Development
An Ad Hoc Staff Development Committee was charged this year to identify training and development needs for the MIT Libraries. Through a series of interviews and focus group discussions, the Committee identified both needs and barriers to participation in staff development activities. In addition, the group identified the resources required to meet the needs identified and opportunities that exist here at MIT and elsewhere.

The recommendations of the Committee include:

- Increase visible, formal support of continuous training in the MIT Libraries by writing and disseminating an official training policy, allocating a significant portion of each staff member's time to training, integrating training and development into the performance planning and evaluation process, and establishing a training and development room for the Libraries that would also serve as the computer training room.

- Identify organizational values by initiating a staff-driven study which would help the staff define, analyze, and come to appreciate the values we share.

- Establish a group to act as a coordinating body for training issues.

- Develop a "train the trainers" approach as an ongoing mechanism for training in the MIT Libraries.

- Establish a continuously updated training clearinghouse in the staff gopher.

- Take action to meet the heavy, ongoing need for computer training by creating a computer training room, adapting the OWL model to create an Athena online consultant (OLC) to allow peer-to-peer problem solving for computer-related topics, developing and maintaining a resource list of computer trainers on the staff gopher, and creating a centralized computer documentation library for use by the entire staff.

- Encourage a feeling of "systemness."

- Improve and enhance interpersonal skills.

- Examine the Libraries' Orientation Program.

- Increase the visibility of the Safety and Security Task Force.

Implementation strategies for the Committee's recommendations will be developed in the coming year.

Safety and Security
A Task Force on Safety and Security was established late in 1992 to review current policies and practices in the Libraries with regard to the physical safety and security of staff, users, collections and property. The Task Force has established several programs to increase awareness of personal security issues, promote safety measures, and educate library staff about self-protection. These include:

- Biannual presentations by a representative of Campus Police on issues of safety and security on the MIT campus.

- Introductory "Street Smarts" session by Model Mugging of Boston, a class in training for self-protection.

- Sample security audit of a library unit by Campus Police.
Installation of "panic buttons" at circulation desks of divisional libraries.

Use of all-lib, the all staff listserv, to share security alert information.

The Task Force submitted a set of interim recommendations for 1995 which will be discussed with Library Council over the summer.

Staff Programs
The Staff Programs Committee finished its third year of activities with a pizza party and staff baby photo identification contest. Other activities for the year included tours of Draper and Lincoln Laboratories, the Media Laboratory, and the Boston Globe. An exhibition of Visual Artists in the MIT Libraries showcased the work of 13 staff members. A Library Staff on Ice event provided an opportunity for staff and families to take advantage of MIT's ice rink.

Sexual Harassment
The Advisory Committee on Sexual Harassment met monthly to monitor the environment at the Institute in the area of harassment, to act as a resource for library staff, and to advise the Director of Libraries on policies and programs. The Libraries participated extensively in the complaint handler program administered through the Office of the Provost.

Space and Facilities
During the summer of 1993, work was completed on upgrading offices in Hayden Library for staff in Gifts and for Science Library staff housed on level 1M. Work began in late spring on the renovation of the conference room on level 2M. A request was submitted to have the room adjacent to Document Services in Hayden basement assigned to the Libraries to be used as an electronic training room. In Dewey Library, work was completed on the Dewey Electronic Reference Center and it opened for use.

Development
A second issue of MIT Libraries Year, this one covering 1992/93 was published. The response to the first issue was uniformly positive and many compliments were received from donors, from MIT community members, and, most gratifying, from directors of other research and academic libraries.

The total amount of funds received for the Libraries through the annual Alumni Association campaign reached a new high. Over $16,000 was contributed during FY94; the highest previous amount in recent years was $10,400 in FY90. The Libraries also received over $20,000 for endowed funds of which $15,000 represented additions to existing funds.

Two grants submitted in FY93 were funded. One was from the Camille and Henry Dreyfus Foundation to support the development of an online databases for chemistry. The other was funded by the National Historical Publications and Records Commission.

JAY K. LUCKER

COLLECTION SERVICES

NOTIS Horizon: Selection, Testing, and Preparation
Selection of and preparation for a new library automation system dominated the collective consciousness of Collections Services staff this year. Many staff were heavily involved in the Cataloging and Acquisitions Groups which worked to evaluate responses to the Libraries' RFP and to assess the potential of three products based on demonstrations by vendors. After the selection of the NOTIS Horizon system, slightly re-configured Cataloging and Acquisitions Groups prepared scripts for testing the system's functions, and reviewed checklists of Horizon functions and compared those with RFP requirements for cataloging, authorities, acquisitions, serials control, and fund accounting. Broader staff participation ranged from optional attendance at vendors' system demonstrations, and subsequent open forums on Horizon implementation, to Windows training sessions. In the last months of the year, selected staff
participated in the development of Horizon hierarchies, tested database migration routines and reviewed migration test records, and carried out preliminary testing of early releases of the Horizon clients. Due to the amount of effort expended and to the general enthusiasm about the Horizon product, the June announcement by NOTIS' parent company, Ameritech, that the development of Horizon would be discontinued, caused considerable dismay. However, much of the year's work will translate forward into the selection and implementation of a replacement system. The Collections Services staff have gained significant knowledge and expertise which prepares the departments well for the future.

**Streamlining Processes Through Automation**

In addition to this expected radical change in the core library system, as other technologies advance and new products or services are offered in the marketplace, Collections Services departments are in an ongoing mode of automating those few processes which are still manual and of upgrading the technology for processes which are already automated.

**Automation of Government Documents Processing**

During 1993-1994, Serials and Acquisitions Services implemented an automated shelf-listing and processing system for depository government documents, one of the most labor-intensive of the remaining manual processes in the Libraries. The system is based on customized Dbase code developed at the University of California, Riverside, used in conjunction with electronic shipping list data purchased from a vendor. Intensive efforts were required on the part of the Documents staff to upgrade an existing database and to test and debug the system. The staff began using the system in January, and, while fine-tuning continues, the system's efficiency has been clearly demonstrated. It takes about one-half to one-third of the time to process a typical shipping list from start-to-finish, and accuracy is improved in both check-in and labelling. In addition, some work reduction has resulted in the divisional and branch libraries where separate databases for documents with short-term retention decisions were formerly created.

**Centralized Server for Local Area Network**

Another significant change in Serials Acquisitions' operations this year was the switch in LAN software from Artisoft's Lantastic to Novell's Netware. This transition was significant not only because of the vastly improved network reliability and response time it achieved, but also because it marked the first collaboration between a library unit and the Systems Office in centralized LAN management. The server for the Novell LAN is located in the Systems Office, and all of the networked data has been mounted there. The transition to Novell went extremely smoothly, and resulted in a significant improvement in operations. Previously, productivity had been restricted by the frequent crashes and subsequent corruptions of data, but these problems receded with the more robust network software and a more powerful server protected from power outages by a universal power source. The time-consuming restoration of backups and recreation of work has been greatly diminished.

**OCLC Telecommunications Link Program (TLP)**

Since 1973, MIT Libraries have accessed the On-Line Computer Library Center (OCLC) database in Ohio to derive and input cataloging records (as well as interlibrary loan transactions) through daisy-chained workstations on dedicated lines. This year, the Libraries shifted to a direct link between MITnet and the OCLC network, using OCLC's Telecommunications Linking Program (TLP). This has enabled access to OCLC from any computer on MITnet, has facilitated the use of a more diverse array of workstations for cataloging, and has resulted in some real cost-savings in payments to OCLC.

**Cataloger's Desktop**

The MIT Libraries served as a Beta test site for the Library of Congress' Cataloger's Desktop product. The Cataloger's Desktop combines LC Rule Interpretations, subject cataloging documentation, MARC format documentation, and MARC code lists into a single online resource. Staff found the Cataloger's Desktop to be a valuable tool, and look forward to additional resources, such as the shelflisting documentation and Conser Editing Guide, that LC plans to incorporate into the product next year. In addition, one of our own staff members has created the Cataloging Oasis, still in an experimental stage, providing on-line access to local cataloging documentation.
Other Streamlining Initiatives

Monograph Binding Workflow
On an experimental basis in 1993-94, the bindery preparation work for paper-bound monographs, previously carried out in all divisional and branch libraries, was carried out centrally in the Binding and Repair Section. Newly cataloged paper-bound books were selected for binding by Bindery staff and sent to the commercial binder before being end-processed for the holding libraries. While a full analysis of this experiment is yet to be conducted, the following benefits can be noted: elimination of work in the divisional and branch libraries, elimination of redundant end-processing, elimination of redundant movement of materials, and the ability to use residue funds for special binding projects. This year, a special project to bind approximately 950 1990 US Census volumes was carried out.

Closing of Exchange Program
As a direct result of the Libraries' budget-reduction mandate, the Libraries' exchange program was terminated at the end of 1993. This program had been used to acquire library materials, primarily from developing countries, by exchanging titles published in the United States for them, rather than purchasing them. Cancellation letters were sent to all of our exchange partners. After subject specialists made decisions, subscriptions were entered for the most important titles with vendors, and internal records were adjusted. Savings resulted from the elimination of a half-time position, cessation of purchase of titles for the exchange partners, and mainstreaming the processing of the most important titles by subscribing to them through established vendors.

Expanded Bibliographic Access to the Libraries' Collections

Original Cataloging
In October, the Bibliographic Access Services Department filled a position for a second original monograph cataloger which had been vacant for two years. In addition, FY 1993/94 was the first full year that original catalogers enjoyed the benefits of workflow efficiencies made possible by the installation of OCLC desktop workstations. As a result, currency in original monograph cataloging was achieved in March.

Special Projects
In a continuing effort to provide records in CD-Barton for all items in the Libraries' collections, several special projects were carried out to convert manual records into online records and to catalog materials which had not previously been cataloged.

- Serials. Under contract to OCLC, a large library network and services vendor in Ohio, 3,500 full records were created for serials which were previously represented only by brief records or by card catalog records.
- Theses. 6,195 records for MIT theses were converted by in-house staff.
- Music scores. 1,567 records for music scores were converted in-house.
- Maps. In an ongoing effort to "mainstream" the cataloging of non-book formats, this year over 300 historic urban plans were cataloged for the Rotch Library. In the process of carrying out this work, several technical details were worked out which will enable staff to handle map cataloging more easily in the future.

Acquiring, Housing, and Preserving Print Materials

Serial Prices and the Materials Budget
The strength of the United States dollar on the European currency market provided relief from the double-digit inflation in serial prices common in previous years. The overall inflation on our serial subscriptions for 1994 was 5%, which enabled us to close the year within our budget. However, with the value of the dollar falling as this report is written, some cancellations may be necessary in early 1994/95.
Even if that is not the case, budget flexibility is greatly reduced, with no inflation funds available for monographs and very limited funds for new serials or electronic products.

**Storage**

In order to accommodate newly purchased materials in the Libraries' crowded facilities, approximately 34,000 volumes were moved to two storage facilities: N57, the RetroSpective Collection (RSC), located one block beyond the MIT Museum, and Harvard Depository (HD), located in Southborough, MA. Special software written by the Libraries' systems vendor (GEAC) to the Libraries' specifications facilitated the record changes required by the move.

**Condition Survey of the Rotch Limited Access Collection**

The Rotch Limited Access Collection is a special collection in the Rotch Library that has been segregated from other materials due to fragility and value. While many of the books in the collection are now rare and collectible, most were originally acquired as teaching tools and are still used frequently today. When the Rotch Library was renovated and expanded in 1990-1991, a special room with optimal climate control was provided for this collection. A high priority for the Libraries now is to discover a funding source to provide preservation treatment for this collection.

To gather data which will be useful in attracting funding and also in planning a preservation project, the Libraries, with the help of an outside consultant, completed a condition survey of a random sample of the collection which had been initiated in 1992/93. In brief, the survey results show that acidic and brittle paper are very severe problems. In 29% of the volumes, the paper is too fragile to be handled and another 28% can be handled only with care. An additional 32.5% have acidic paper, leaving only 10.5% of the collection with stable paper. Damage to bindings is also a serious concern and the data show that 45% of the volumes need binding repair. Only 6.5% of the 3,547 volumes are in excellent condition; 3,316 volumes need some level of repair. With the data from the survey and estimates for conservation treatments, the Libraries will have an accurate way of projecting costs and a solid information base for grant applications and appeals to individual donors.

**Acquiring Electronic Resources**

The Libraries continued to purchase or lease electronic information sources for use within the Libraries. The following new CD-ROM products were added to our collections in 1993-1994.

*ArtBibliographies Modern on Disc* - Abstracts of the current literature of modern art, photograph and design; covers the period 1900 to date. (Rotch)

*Compustat PC Plus for Windows* - Standard and Poor's financial analysis data; contains financial and market data for United States and Canadian corporations, banks, S&Ls, business segments, geographic areas, industry composites, and indexes, plus data on inactive companies. (Dewey)

*Design and Applied Arts Index* - The largest design and applied arts database available; covers publications in industrial, graphic and information design and the minor arts. (Rotch)

*MathSci* - International coverage of mathematics research literature and mathematically related research in computer science, statistics, econometrics and other disciplines. (Science)

*METADEX/Materials* - Worldwide technical and industrial literature in metallurgy, polymers, ceramics, and composite materials; intended for use in the design, construction and operation of structures and related materials science and engineering practices. (Science)

In addition, late in the year, in a joint project with Information Systems, the Libraries acquired the *Oxford English Dictionary* on tape for access via MITnet.
Information Resources on the Internet
The scholarly resources available on the Internet expanded dramatically during the year. Selecting information resources from this rich, new source and organizing access to it is an expansion of the Libraries' traditional role. To prepare staff to carry out this role, a second Internet Resources Training course was presented to 50 participants from throughout the Libraries. A Libraries' staff member designed and coordinated the course. The first three classes focused on Athena and were taught by an Information Systems' staff member. Subsequent classes were taught by various Libraries' staff members. The purpose of the training was broad-based skill-building to enable staff to incorporate networked resources into our information services and collection management, with a special emphasis on contributing to MITosis, a library Gopher.

MITosis was developed this year by a task force (GARP) consisting of three public services librarians with selection responsibilities, one cataloger, and one person from the Libraries' Systems Office. Late in the year, teams of subject specialists and technical services librarians were created to continue to add to MITosis, which will become a public resource sometime in the summer of 1994. The ultimate goal is to have all subject specialists and all catalogers actively involved in the work of selecting and organizing access to networked resources.

CAROL J. FLEISHAUER

PUBLIC SERVICES

Reorganization
This year's Public Services retreat focussed on how we are organized to deliver services to our users in terms of our committee and task group structure. This analysis identified the need for a planning and policy group which was more nimble, less bureaucratic, and more inclusive. The result was the formation of the Public Services Action Committee (PSAC) chaired by the Associate Director for Public Services. Membership includes the heads of the divisional libraries and their reference/information services coordinators; the heads of Document Services, the Computerized Literature Search Service, and the Systems Office; and the Institute Archivist and the Reference Archivist. PSAC's charge:

- Envision and articulate the future of public services for the MIT Libraries.
- Develop and implement public service policy for the MIT Libraries.
- Through the work of task oriented groups, committees, and individual initiatives, orient, educate, and actively promote the services of the MIT Libraries.
- Foster innovative and creative approaches to anticipating and meeting the information needs of the Libraries' clientele.

With the exception of the Circulation Committee and its Reserves Working Group and the Branch Librarians Group, all other public services committees and groups have been disbanded. The work of the Branch Librarians Group has been refocussed so that the entire organization can benefit from the "special librarianship" orientation of their day to day work. They will be organizing three or four presentations each year showcasing the nature of their services and work with their clientele.

The PSAC model is new and evolving. The group meets weekly for one hour to share information, do its work, and fine tune the process by which we manage public services for the MIT Libraries.

Reference In Cyberspace
The past year reflects the continuing expansion of services to our users over the campus network in a variety of exciting and innovative approaches:
OCLC's FirstSearch has been enthusiastically received by the MIT community. All databases have been available over the campus network and searching has grown to over 4500 searches each week. The most frequently searched databases: WorldCat, ArticleFirst, MEDLINE, and Inspec. Document delivery services attached to FirstSearch, including the ability to download requests to our Interlibrary Services Section, have also been well received by the community as reflected in the increase in requests for materials not owned by MIT. Development work with Information Systems and OCLC has focussed on the use of the University of Washington's Willow interface to search FirstSearch's Z39.50-compliant databases, with the goal to reduce the number of different interfaces with which our users must interact. Work in the coming year will center on exploring funding models for this very successful service.

Online With Libraries (OWL), our electronic reference facility, continues to be very popular with our community. Over 600 reference transactions were logged in the past year, ranging from basic information to in-depth research assistance. Sample questions received this year:

- Do you have the formula for a geometric probability distribution handy?
- I wanted to find out if there is an index of some sort that will provide me with recent publications on soil fungi and their uses in the biotechnology industry.
- How would I best search for a play by Thomas D'Urfey titled "Love for Money or the Boarding School?"
- I am looking for a reference which will describe how to design heat transfer fins for the inside of a cylinder. The configuration is a cylinder of diam. 2.75 in. through which air is being blown. I need to increase the heat transfer rate and thought fins would work.

The coordination and management of the OWL service was addressed this year and the new model consists of an OWL Coordinator and an OWL Team. This team is responsible for developing procedures and guidelines for the OWL service, developing and maintaining a stock answer file, developing and maintaining OWL documentation, participating in future development of OWL, training of new staff and continuing education of all staff in OWL procedures and policies, day-to-day maintenance of the OWL service, and participating in OWL promotional activities. We continue to be grateful for the support and enthusiasm of Anne LaVin of Information Systems, one of the developers of the OWL service.

MITosis, the Libraries' experimental Gopher, has been in prototype over the past year as the staff becomes fluent in the technological, organizational, and social issues involved in working with information in cyberspace. The confluence of the work of GARP (Gopher and Archie Review Panel) and the Internet Resources Training initiative have put us in the forefront in this area in terms of staff skills; team approach to tasks; collaboration among reference/subject librarians, catalogers, and systems staff; and leadership in the campus rethinking of the campus-wide information system. The work on MITosis has also challenged the entire organization to think about the future of information access here at MIT. The year ahead will see public access to MITosis, the continuing incorporation of mosaic, and collaborative work on MIT's CWIS.

Reference In Real Space
All of the accomplishments in electronic reference augment "traditional" reference services provided onsite. In fact, network access to information increases both the numbers and complexities of onsite use. Library users have always needed training in accessing and evaluating information. That task becomes a challenge with library users at the end of an electronic connection. Approaches have included traditional library instruction sessions in the library and in the classroom, special mini-course offerings during Independent Activities Period, presentations to groups of faculty, etc. Much more education is delivered on an individual basis—either in the reading rooms or in the office or laboratory space. The nature of those interactions reflects the changing role of the reference librarian who now provides access to the world of information; technical savvy about how to connect to, download, and incorporate information; and evaluative skills with which to make decisions about both content and format, striking the balance between electronic and paper resources. As the reference librarian's role changes, we try to anticipate
and meet staff needs in terms of training, equipment, support, appreciation, and recognition. It is both an exciting and chaotic time in public services and the staff finds reassurance in the fact that here at MIT excitement and chaos are integral parts of the environment!

Service in assisting the MIT Administration in its work has been a strong tradition in the MIT Libraries. In addition to our traditional roles of supporting teaching and research, the staff thrives on opportunities to provide service to the administrative offices on campus. A major undertaking this year involved work done by the Institute Archives in searching the records of MIT's research laboratories as part of the investigation by the State of radiation experimentation. The Computerized Literature Search Service this year worked on special projects for the Provost's Office, Office of Sponsored Research, Corporate Development, the Industrial Liaison Program office, the Technology Licensing Office, and many academic departments. Other assignments included gathering information about MIT for the Aga Khan's staff in preparation for his Commencement visit to campus, many computerized literature searches and analyses on a variety of topics for a variety of offices, biographical information for a wide range of administrative needs, etc.

Service to interdisciplinary laboratories and centers has been the focus of a public service initiative this year. An issue identified during the conduct of the Information Services Study was whether interdisciplinary research alters the kinds of information and services necessary. A subgroup of PSAC has been working to identify such laboratories and centers and to articulate a set of questions to use in a data gathering exercise. Two "test" centers were identified, the Center for Global Change Science and the Biotechnology Process Engineering Center. One interview has been conducted to date. The coming year will see the completion of this work and the refinement of the methodology for determining the information needs of emerging laboratories and centers.

The MIT Libraries have always enjoyed an open door policy with neighboring institutions of higher education and members of the general public. In addition to those individuals who are using the Libraries as a result of their institution's membership in one of a variety of reciprocal programs, the past several years have seen a dramatic increase in the number of non-affiliated visitors. PSAC has spent some time this year discussing the issue and has drafted a policy statement on service to visitors which articulates levels of service which non-affiliated users can expect. This is the first step in our process of ensuring that the staff is free to provide members of the extended MIT community excellent reference service.

**Document Services And Computerized Literature Search Service**

The name of the Microreproduction Laboratory was changed to Document Services to better reflect the current nature of the work of that department. Still providing a wide range of services in microformats and still very much involved in preservation both at MIT and nationally, the department has taken advantage of emerging technologies to take a leadership role in providing access to information produced or stored here at MIT.

Participation in the Institute's Publications Services Review Group (PSRG) has resulted in a larger role for the Libraries in terms of storage and distribution of MIT's research reports. At the same time, Document Services' participation in the (Advanced Research Projects Agency) ARPA-funded Computer Science Technical Report Project has given the department the necessary technical expertise in scanning and storage of documents. Since the completion of the work of PSRG, formal distribution arrangements have been made with several campus publishers. This program will be expanded in the coming year.

Work was initiated this year to formally merge the Computerized Literature Search Service with Document Services. The two units have enjoyed a close working relationship, each holding pieces of the "information puzzle." The formal integration of the two services paves the way for a range of fully integrated services for both MIT users and the research world beyond MIT.

**Compliments From Our Users**
The work that goes on at our public services desks and over the network to assist our users has resulted in the following feedback from them:
"I...always feel that a conscientious, good-faith effort has been made, with a pleasant, competent manner."

"...have always been extra-helpful to me, whether in person or over the phone."

"It is nice to know that MIT has librarians who are willing to help panicking students in the middle of the night, up to speed with current electronic technology and can use computers creatively to solve problems!"

"...a job well done."

"...appreciate the exceptional people you have at the MIT libraries...people...that make your jobs a lot easier."

"...I'd like to congratulate the MIT library staff for their aggressive proactivity in turning developments in information technology into real service improvements for library patrons. Y'all are tops with me."

"...I must say that I have never met a MIT librarian who was not competent and helpful."

"I don't have the least idea how a library is run, but whatever it is you are doing over there, it's awfully good for the library's users."

"Thank you very much for your help, now and in the past. It is really invaluable to our research."

"Thanks so much...for all the effort you're putting into this."

"I must admit I am impressed...keep up the good work."

"Wow. I am pleased. How come librarians know everything?"

DAVID S. FERRIERO

SYSTEMS AND PLANNING
The annual report process this year is different for Systems and Planning. In FY 94 the Libraries designated the Library Systems Office as a full-fledged department with membership on Library Council. In normalizing the place and role of the Systems Office, the Libraries have recognized the integral role and almost ubiquitous presence that Systems fulfills in the Libraries' operations. This also permits the Head of the Systems Office to compile and write the annual report for the Office.

Because Systems Office activities are now represented in its departmental annual report, this annual report will cover broadly the activities and issues related to the Associate Director for Systems and Planning and to the Libraries' overall activities in these areas. There are brief sections below related to organization, systems activities, the DLI and collaborative relationships, planning, and technology development efforts.

But first the BIG news.

HORIZON: Rise and Fall
The significant activity for the Libraries in this past year was the selection, participation in, planning for, implementation, and, sadly, the aftermath of the NOTIS Horizon system. MIT chose the NOTIS Horizon system following a superb selection process that was highlighted by involvement by staff from throughout the Libraries, IS, and the Institute, and which included a variety of activities and products that were in keeping with the standard of excellence at MIT. The MIT Libraries and Information Systems made the best judgement at the time in selecting Horizon.
The Horizon Beta process through the fall and winter was invigorating for the Libraries. Meeting challenges, making decisions, and moving forward were characteristics of this period. We learned firsthand of the bumps and bruises of the beta process, and we learned what it is like to be a leader in a process, as NOTIS looked to MIT to set a high standard of participation.

The Ameritech announcement in June that development of Horizon would cease was a surprising shock to all of us. Of the good that this decision brought, there were several areas: the sense of ownership in the project strongly shared by the Libraries and IS; the systemness in coming together to learn about the decision, to cope with the anger and frustrations; and the resolve to recover and move forward were emotional and moving elements in the Libraries during this period. All staff are to be congratulated and applauded for a superb job.

As we move forward to determine our new vendor, it is worth repeating that we will not be starting over and that there are several key issues and advances that the Libraries have addressed during the Horizon beta effort:

a. The Libraries' technology infrastructure has been totally revitalized including new machines and network drops throughout the system. Libraries' staff have had training and are taking great advantage of this new technology base to provide better services.

b. We have deepened further our collaborations with Information Systems. We have drafted service level agreements for support and operations of the Libraries' servers; we have developed a continuous funding model based upon the Athena renewal model that ensures a renewable strategy for the Libraries' technology; we have involved IS staff in several standing groups in the Libraries. The Libraries and IS together "own" this activity.

c. Most importantly, the Libraries' staff have responded extraordinarily well to this new environment. We are working in cross-functional and cross-organizational teams; we are making sound decisions with the data we have available; we are acting quickly and more responsively; the staff have been invigorated by this process.

Organization

Library Systems Office
Systems staff and activities have become integrated in almost every aspect of the MIT Libraries and have expanded through the Distributed Library Initiative to include an increasing role and presence in the life of the Institute. In addition to the designation of the Library Systems Office as a department in the Libraries, Systems staff have become involved in an increasing number of Library-wide activities. The Horizon beta site effort involved all Systems staff to the fullest extent possible: technical, organizational, operational, administrative, and managerial. Systems played a significant role both in leading components of the project and coordinating and contributing to others. For example, Systems staff coordinated the purchase and installation of over one hundred seventy 486 level microcomputers and coordinated with IS the installation of MITnet drops. Systems staff organized and implemented a thorough Windows training program for all staff. As always, the support and maintenance of our GEAC 8000 activities continued unabated, even as Systems staff worked at peak effort on Horizon. Systems also installed a prototype Novell LAN in the Systems Office and extended to Serials and Acquisitions Services in order to understand and gauge the effort necessary to support a large, library-wide, LAN. Systems has also moved into the UNIX world in a significant manner. During the year two athena workstations were purchased to support the Libraries Staff Gopher and the public service MITosis resource. Systems has re-organized staff to provide support for these new services and has integrated their support into the daily regimen of the office.

Libraries' organization
Systems increased its visibility and contributions to the Libraries' intensive committee and task group structures. Systems contributions were to provide technical insight, new perspectives, and new support for the Libraries' activities. Please refer to the staff activities in the Systems Office Annual Report.
Distributed Library Initiative (DLI)
DLI involvement became more intense in this past year. The DLI components of the Horizon project involved frequent collaboration with Information Systems and other groups on campus. The DLI Steering Committee came to closure on the DLI Vision and made the final decision on the New Operations System, based upon the recommendations of the RFP and new system evaluation groups. The DLI Coordinating Committee met throughout the year to integrate a variety of efforts including TULIP, the ARPA CS-TR Project, OCLC and our Newton Search Engine, Service Level Agreements with IS Operations Services in W91, networking coordination with Network Services, licensing efforts with the Intellectual Property Office and with the Office of Purchasing and Stores. The Electronic Library Development Group (elibdev) met throughout the year to look at new systems and services, including the Horizon clients, TULIP, DARPA CS-TR, electronic forms, and electronic reserves.

Systems Activities
The major news of Horizon is covered in the organization description above. It should be mentioned here, however, that the beta site effort increased the awareness and knowledge of the Libraries' staff and our understanding of our own work and processes.

Staff worked to create new system tables, hierarchies, and security levels for Horizon. Even though we will not be implementing this system, the cognitive processes we engaged to determine this information will be useful in whatever system we choose. The network awareness and knowledge of the staff has grown tremendously with the installation of the network drops and the new machines on the desks.

In other DLI activities, it is worthwhile to describe several projects in detail:

- **TULIP.** The University Licensing Program, sponsored by Elsevier Science Publishing to place page images of Elsevier journals in the field of Materials Science, continued to make progress. A cross-functional TULIP implementation team was formed under the leadership of the Associate Director for Systems and Planning. It is composed of Libraries' staff, IS programming staff, and a liaison from the Materials Science dept. This group formulated a plan of action for the year and worked to develop a fully functional prototype for the TULIP images. A new image browser was written to work with the WILLOW interface and with Mosaic, and the group hosted a demonstration of the system for the Materials Science community - faculty, graduate students, and undergraduates. Most of the TULIP datasets were brought online, and a logging mechanism was developed that will provide management data while also protecting the privacy of users. The page browser work was completed and brought online, providing very fast access to the TULIP pages. We are distributing a survey to participants to learn more about how this service is used and to gather feedback about improving it. We continue to work with Elsevier to finalize our license agreement, and Elsevier representatives visited MIT several times this year. TULIP will be ready for a full-scale prototyping test for the community this fall.

- **CS-TR project.** This was the first full year of active work on this project, a five-campus consortium effort to place images of technical reports in computer science and artificial intelligence online. The Libraries have been working with Professor Jerry Saltzer of LCS and Library 2000 on this effort. The primary library work has been to devise and build a production-level scanning station that uses readily available components. This station was installed in Document Services and has been in testing and operation since this winter. This spring, a presentation on this project was given at the Coalition for Networked Information meeting in Washington. The MIT Libraries participated in research project meetings at CNRI, the contract agency for the grant, at Stanford, and at Carnegie-Mellon University. Work on the construction of a production-level scanning station in the Libraries' Document Services area continued and work with the Library 2000 project staff under the direction of Professor Jerry Saltzer continued.
WILLOW. The Libraries and IS continued to work with the X/window bibliographic interface developed at the U. of Washington. MIT developed the Z39.50 client software for Willow, and the Libraries and IS began work at the end of the year to place a networked version of the MIT catalog online using Willow and the Newton Search engine from OCLC. Development activities for this service will include an update mechanism and a link to circulation status information.

FirstSearch. Systems developed a script to protect the MIT password to FirstSearch and placed this into production. In addition, IS developed the software driver necessary in order to connect Willow with the FirstSearch database Medline.

Magnetic ID's. Systems and the Circulation Coordinator for the Libraries worked with a consultant and with the head of Housing and Dining Services to support the use of the Libraries' patron number as part of the magnetic stripe used in the new MIT ID. This was a difficult effort, but the Libraries have remained good partners throughout the development of this new service.

DLI and Collaborative Relationships
The Libraries continued its partnership with Information Systems to provide electronic library services to the MIT community. In addition to the organizational and system activities related to the DLI above, the Libraries were also involved in other efforts with IS:

Electron classroom. The Libraries reached agreement with Academic Computing Services to permit use of the Dewey Library Classroom (E53-220) as an Athena electronic classroom. This cooperative effort will increase the Athena presence on east campus and will provide the Libraries with preferred scheduling for that space.

Computing Activities report. The Libraries have contributed regularly to the quarterly Administrative Computing report. In this fashion the Institute remains aware of computing activities within the Libraries and the Libraries contribute to the efficient use and allocation of computing resources on campus.

Funding model. As part of the New Operations System project, the Libraries developed a continuing budget model that will support the capital purchase of the system as well as an ongoing renewal segment of the budget. This will enable the Libraries to track and expend its computing dollars on a more consistent and regular basis. The budget is composed of an ongoing contribution from the Provost's Office and re-allocated contributions from the Libraries' budget.

Planning
The Libraries' annual planning effort included this year work toward a new Vision for the Libraries. Primarily through the efforts of Library Council, this new vision will serve as a cornerstone for the Libraries' Strategic Planning effort to replace the 1988 Strategic Plan. This Vision process included the use of its Vivid Description at the Spring 1994 Library Council Retreat that included Associates from around the Libraries. The Vision will be distributed and discussed by the Libraries' staff. In the fall, the Libraries will use the new Vision to begin its Strategic Planning effort.

Technology Development Program
The Associate Director for Systems and Planning worked with Mary Leen of the Development Office and with the Director of Libraries to take forward several development efforts this year. Primary among those was the preparation of a proposal to the Mellon Foundation for funding of the DLI. While initially too large in scope for Mellon, at year's end, the Libraries were crafting another proposal for President Vest to take forward.

The Libraries participated in one MIT proposal to the Digital Library Initiative sponsored by the National Science Foundation (NSF). The Libraries worked with the Center for Advanced Engineering Studies and
the Center for Technology, Policy, and Industrial Development to include a component for Digital Librarian in their multi-media proposal. This proposal was not selected for funding.

The Libraries prepared an invitational proposal for the Booth-Ferris Foundation to fund a LAN for the Libraries. At year's end, we learned through the Development Office that Booth-Ferris no longer funds library projects.

This was a learning year for the development of library technology proposals to the Development Office. Several efforts are underway presently which will be forwarded later this summer.

**Issues For Next Year**

This next year will require the Libraries to think carefully about the support - both in staff and money - of this technology base, and to understand the different components of our technology base - the network, the machines, the software, the data content, and how we can fit it all together more coherently and cohesively.

- **Process and pace of continuing our new system search.** We must move quickly in searching for our new system in order to move the Libraries and the DLI effort forward and to regain the pace of our development. We must also move forward as quickly as possible because our current system, the GEAC 8000 continues to age. The original goal set for replacing the GEAC 8000 was December 1994; we must try to stay as close to that target as possible.

- **Communication and buy-in.** With the setback caused by the Horizon decision, we must work very hard to keep staff involved and informed. The enthusiasm and effort by Libraries' and IS staff has been truly heartening and their efforts will carry us forward.

- **Support.** How will the Libraries and IS provide support for this increasingly extensive and complex technology?

- **Capacity.** The Libraries and IS are working together to understand the issues related to capacity planning for an increasing amount of electronic information. Through the DLI Steering Committee, this issue will be explored and options for its solution will be examined.

- **Coordination.** Maintaining progress in each of these project areas requires close coordination and collaboration so that we can maximize efforts and learn from each activity.

**Conclusion**

This was a year of great accomplishment for the Libraries and its technology program. The unfortunate news about the demise of the Horizon system notwithstanding, the Libraries made significant progress toward its goal of being a leader in library technology and revolutionizing the manner in which the MIT community receives library information.

GREG ANDERSON
Lincoln Laboratory is operated by MIT as a Federally Funded Research and Development Center for performing research and development in advanced electronics. During the past year, agencies of the Department of Defense (DoD)—namely, the Air Force, the Army, the Navy, and the Advanced Research Projects Agency (ARPA)—supplied approximately 88% of the Laboratory’s budgetary support. The Federal Aviation Administration (FAA) provided most of the non-DoD support. The number of Cooperative Research and Development Agreements (CRDA) at Lincoln Laboratory with industry has increased to seven with three completed and additional CRDAs in process. For the federal fiscal year 1993 Lincoln Laboratory received $359.9 million, supporting the efforts of 827 principal technical staff, 84% of whom hold advanced degrees.

The following administrative changes occurred at the Laboratory Steering Committee level during the year: Dr. David L. Briggs became Assistant Director; Dr. Wade M. Kornegay became Head and Dr. Kenneth R. Roth became Associate Head of the Radar Measurements Division; Dr. David C. Shaver became Head of the Solid State Division; and Mr. Lee O. Upton, Jr., became Head and Dr. Kenneth D. Senne became Associate Head of the Air Defense Technology Division. Professor Alan L. McWhorter became the Laboratory’s first Division Fellow.

Technical work areas at the Laboratory include radar and optical sensors, measurements, and systems; communications; signal design and processing; lasers; solid state devices; digital technology, circuitry and data systems; and tactical control systems. Unclassified highlights of several accomplishments during the past year are summarized below.

**SURVEILLANCE TECHNOLOGY**

High-Definition Vector Imaging
In work sponsored by the DoD, Lincoln Laboratory has developed two-dimensional superresolution processing techniques that manipulate synthetic-aperture-radar data so as to produce a higher signal-to-clutter ratio on objects of interest than is obtainable with conventional processing techniques. A theoretical understanding of the potential has been established, and impressive results have been obtained by processing real data from the Laboratory’s experimental radars. The techniques, although computationally intensive, can operate in real time with state-of-the-art computers; it is expected that many other image and data processing applications will be found for this class of techniques.

**NOAA Sensors and Spacecraft Program**
This program was initiated at Lincoln Laboratory in 1992 to support the National Oceanic and Atmospheric Administration (NOAA) in their development of the Geostationary Operational Environmental Satellite (GOES). The initial activity was directed at supporting the GOES contractor to ensure delivery of the first flight model, GOES-8 which was launched on 13 April 1994 into geostationary orbit. Lincoln Laboratory is providing technical support to the contractor during characterization testing of GOES-8 and is also supporting GOES-J, the next geostationary satellite in the five satellite series, by analyzing data from sensor tests and providing designs to improve reliability and performance.

The Laboratory is evaluating design modifications to the GOES instruments that will improve sensor performance. An imager upgrade study is under way to assess the impact of adding IR bands to the imager and doubling the imaging rate. In addition, a study has been completed that evaluated an interferometer modification to the GOES sounder that provides increased IR spectral resolution to better estimate vertical temperature and water-vapor profiles of the atmosphere. A breadboard of the interferometer hardware is being constructed and will be tested at the Laboratory.

**NOAA Advanced System Development**
The NOAA Advanced System Development program at the Laboratory supports NOAA’s Polar Operational Environmental Satellite (POES) program. The National Weather Service has a requirement to produce temperature profiles of the atmosphere that achieve an RMS error of 1K in 1-km-thick layers in lower troposphere. NOAA’s present IR sounders cannot achieve this performance because of limitations in spectral resolution. Studies at the Laboratory have confirmed that an interferometer can meet these requirements. As a consequence, the Laboratory is developing a breadboard interferometer aimed at demonstrating survival through launch and proper operation in space environment.

**Space-Based Visible Sensor**
Lincoln Laboratory has been engaged in the development of technology and techniques leading to the potential deployment of Space-Based Electro-Optical Sensors for Space Surveillance. These sensors, when deployed, would add significant capability to the current ground-based sensor network. The concepts being pursued require optics with high straylight rejection performance, focal planes with large number of pixels in IR and visible bands, and signal processing technology to provide real-time target detection and clutter rejection capability.
An experimental sensor payload, Space-Based Visible (SBV) sensor, has been built and will be flown on the Midcourse Space Experiment (MSX) satellite for space demonstrations. The satellite is scheduled to be launched into a 990-km sun-synchronous circular orbit for five-year operations in late 1994. The SBV sensor, operating in the visible wavelength, uses focal planes made from high-sensitivity, high-pixel-density Charge Coupled Device (CCD) chips. These chips, fabricated at the Laboratory, are the best currently available for low background applications. The SBV sensor also includes on-board processors with algorithms to provide automatic target detection, clutter cancellation, and sensor command/control.

**Theater Missile Defense (TMD) Measurements**

During the past year Lincoln Laboratory initiated a new program in optical measurements for TMD. This program uses high-speed visible and infrared cameras mounted on the Sea Lite Beam Director at White Sands Missile Range (WSMR), NM. The combination of the cameras and the large beam director makes it possible to obtain high-spatial-resolution images of missiles launched at WSMR.

**Atmospheric Compensation**

Research in adaptive optics for atmospheric compensation continues at Lincoln Laboratory. The focus of the current effort is on long-path propagation through weak turbulence. The principal difficulty in this scenario is strong scintillation (or amplitude fluctuations), which can introduce fundamental limits to how well an adaptive-optics system can correct for atmospheric distortions.

Experiments are being conducted along a 5.5-km horizontal path at the Firepond facility in Westford, Massachusetts. The experiments use a 241-channel adaptive-optics system. During the past year the experiments achieved a significant milestone in demonstrating, for the first time, that atmospheric compensation is possible in strong-scintillation conditions. Future experiments will fully quantify the degree of correction possible as a function of scintillation strength.

**Environmental Monitoring**

During the past year Lincoln Laboratory initiated a new effort in applying DoD developed technology to important environmental problems. The major experimental activity on this new program was airborne monitoring of the New England coastal region by using a lidar system. This system employs laser-induced fluorescence to measure the concentration of phytoplankton in the water.

The airborne-lidar measurements were highlighted by the first-ever airborne demonstration of a pump/probe technique to measure phytoplankton activity. Data important to the Boston Harbor cleanup were taken in Boston Harbor and Massachusetts Bay. Data were also taken in the important fishing area of Georges Bank. The Laboratory plans to extend the airborne monitoring to include additional measurements (e.g., dissolved organics, depth-resolved temperature profiles) and to make measurements at other locations.

**COMMUNICATIONS AND NETWORKING**

**Optical Communication**

Lincoln Laboratory's concept for modular design of satellite optical crosslink packages has been demonstrated in a fiber-based modular prototype optical crosslink package incorporating a number of previously developed space-qualified assemblies. The rapid assembly of this prototype demonstrates both the value and flexibility of the modular concept and Lincoln Laboratory's unique capability in space laser communication systems. The fiber-optic interconnection of separate transmit, receive and pointing-and-tracking modules provides an open architecture for easy incorporation of separately developed subsystems into a system. This approach potentially allows multiple suppliers of these modules with simple interfaces and the competition will lower the costs and risks to the government and commercial users. The prototype is also being converted to 1.5-μm wavelength directly to utilize the technology base being developed for terrestrial telecommunications.

Data rates well above 1 Gbps are emerging in both defense and civilian communications. The Laboratory has both developed components and demonstrated significant new capabilities for high-rate optical links. Earlier development of a "tapered gain region" high-power semiconductor optical amplifier has been extended to produce 0.98-μm semiconductor diode-laser pumps for Erbium fiber-optical amplifiers often used as optical power sources and amplifiers in high-data-rate optical communication systems. Lincoln Laboratory recently demonstrated a 1-W-output Erbium Doped Fiber Amplifier (EDFA) using semiconductor laser pumps and has also demonstrated record sensitivities for 10-Gbps optical communication using an EDFA as a receiver preamplifier. A 1-Gbps single-chip error-correcting coder/decoder has been developed and tested on free-space and optical-fiber communication systems and shown to offer a number of advantages ranging from increasing receiver sensitivity by more than 3 dB to doubling the number of wavelength-division multiplex channels that can be accommodated in a single fiber. These technologies for high-rate communication in both free-space and optical-fiber systems are applicable to both military and civilian needs in space and terrestrial communication networks.
All-Optical Fiber Networks
A consortium of Lincoln Laboratory and MIT campus groups with Digital Equipment Corporation and American Telephone and Telegraph as industrial partners has begun development of an all-optical fiber network. The Laboratory is building the network test bed to demonstrate this scalable architecture using technology developed by consortium members. As part of a national infrastructure, all optical networks could provide links for both civilian and military telecommunications and data processing systems and would enable more timely and low-cost dissemination of information. Lincoln Laboratory has also begun development of technology for 100 Gbps and optical switching technology to interface these high-rate systems to lower-data-rate long-haul or end-user systems. For high-rate switching, the Laboratory has demonstrated an all-optical AND function using a multiple-quantum-well thin-film material as a nonlinear optical material in a single-arm interferometer configuration that permits optical switching at clock rates much higher than the semiconductor carrier lifetime.

The all-optical network architecture has also been extended for the distribution of wideband analog signals such as TV signals in the local area. Signal fidelity can be preserved with the use of new system techniques. A test bed will be constructed to demonstrate this architecture next year.

Satellite Communications
The Satellite Communications Technology Program involves the identification, development, demonstration, and transition (to sponsors and industry) of advanced concepts and technologies for future satellite communications systems. The program is responsive to evolving satellite communications service trends and challenges, including the performance-related goals of increased capacities (especially to small, perhaps mobile terminals), interoperable networking (where satellite communications extend national/international information networks to remote areas and/or mobile users), robustness against co-user as well as intentional interference, and flexible configurations that can readily accommodate evolving requirements. The Laboratory is also paying particular attention to the need to lower the cost of future satellite communications systems by emphasizing concepts and technologies that would permit smaller, lighter-weight, lower-power implementations. Lincoln Laboratory's efforts will support the government's mid-1990s decisions concerning modernization of the MILSATCOM architecture. Many of the concepts and technologies that are being developed are also applicable to the emerging commercial wireless and mobile satcom services. Many initiatives to transition DoD-developed technology to help U.S. satcom industries compete in the commercial sector are under way.

Four technologies are critical to meeting the current satcom system challenges: adaptive-coverage antennas, lightweight signal generators, low-power signal processors, and reliable efficient transmitters. Ultra-lightweight waveguide and feedhorn technologies have been used to reduce by an order of magnitude the size and weight of the beam-forming networks in high-performance adaptive-coverage antennas. Emerging opto-electronic technologies are being employed in a variety of antenna applications ranging from systems that offer the potential to achieve significantly greater levels of adaptive suppression of interfering signals to those which could lead to considerable reductions in the costs of agile-beam phased-array antennas (by performing both signal distribution and phase shifting optically). Direct digital synthesis techniques and hybridized RF/IF circuits have been combined to lower by a factor of 6 the weight of fast-settling frequency synthesizers. Similarly, application-specific-integrated circuit (ASIC) and multi-chip-module (MCM) technologies are being incorporated into high-speed, low-power satcom signal processors that have the potential to reduce weight by a factor of 10 while extending data-rate capability by a factor of 1000 (to a few Mbps per channel).

The spread-spectrum modulation and signal processing and message switching/routing features of the Lincoln Laboratory FLTSAT EHF Packages (FEP) and Single Channel Advanced Man Portable (SCAMP) terminal have been incorporated into MILSTAR, which is a satcom system being deployed to carry the government's most critical strategic and tactical command and control communications. Additional technology transition activities have involved the Laboratory's Low Temperature Growth (LTG) GaAs power-amplifier-device technology, which is being transferred to a commercial foundry.

A new program has been initiated to investigate the possibility of achieving high data throughput in a band-limited channel with the use of polarization diversity and bandwidth-efficient modulation. Two independent data streams transmitted in the same channel on orthogonal polarizations will develop crosstalk due to the depolarizing effects of atmospheric propagation anomalies caused by ice, rain, and scintillation. The utility of this form of diversity communications depends on the extent of atmosphere-induced crosstalk that is to be evaluated by utilizing a ground-based test facility.

The Laboratory's terminal technology work has resulted in initial production of a manportable MILSTAR terminal based on the Lincoln 30-lb SCAMP design. We are extending the current design to incorporate wireless I/O operation and developing the technology required to realize this and other functional enhancements with components that are lighter, low power and much less costly. We are also developing an extremely reliable low-cost EHF transmitter based on a novel active aperture-feed concept for medium data rate (>1 Mbps) satcom terminals; this transmitter should be easily producible by the electronics industry.
AIR TRAFFIC CONTROL

Satellite Navigation Systems
The exploitation of the U.S. Global Positioning System (GPS) and its Russian counterpart (GLONAS) for civilian aviation applications continues to be addressed in an effort sponsored by the Federal Aviation Administration (FAA). The Laboratory has established the transformation required to align the geodetic reference systems that underlie the U.S. and Russian systems by position. The Laboratory has demonstrated the use of a differential GPS system for tracking of taxiing aircraft and in support of non-precision approaches, first at Hanscom Air Force Base and then at Boston's Logan International Airport. A new GPS signal processing technique was also developed that improves the achieved vertical accuracy by about a factor of 2.

Surveillance Systems for Safety and Air Traffic Control
This year a number of systems that were developed, prototyped, and tested at Lincoln Laboratory for the FAA were brought into operational use. The first of several hundred Mode-S interrogators built by Westinghouse and Unisys that support the Discrete Address Beacon System (DABS) replacement for the Air Traffic Control Beacon System (ATCRBS) were brought on line. The initial deployment of the 47 Raytheon-built Terminal Doppler Weather Radars using Lincoln-supplied microburst-detection algorithms took place. The deployment of the Westinghouse Airport Surveillance Radar, model 9 (ASR-9), which uses the MTD (Moving-Target Detector) signal processor developed at Lincoln Laboratory, continues. Finally, all of the large passenger aircraft flying in the U.S. will by the end of this year be equipped with the Traffic Alert and Collision Avoidance System (TCAS) that Lincoln Laboratory developed in conjunction with MITRE. Several firms, including Bendix and Collins, built this equipment in accordance with a government-published specification that incorporates the coordination logic developed at the Laboratory.

Aviation Weather Detection and Prediction
A multi-year program to improve the FAA’s capability to detect and predict weather conditions impacting aviation utilizes test-bed radars and advanced signal and data processing to provide weather information automatically for air traffic controllers, pilots, and air traffic control automation systems. Lincoln Laboratory has developed wind shear detection and storm motion algorithms that will be utilized in the Terminal Doppler Weather Radar (TDWR) now deployed at major airports. When combined with suitable signal processing techniques to estimate low-altitude Doppler velocity, these algorithms enable the FAA's Airport Surveillance Radar (ASR) to be equipped with a Wind Shear Processor (WSP), providing similar wind shear warning capability at the nation’s smaller airports. Algorithm refinement is ongoing and acquisition of 33 or more WSPs by the FAA is slated to begin in 1997.

An Integrated Terminal Weather System (ITWS) is being developed to improve delineation of hazardous airspace and to provide short-term forecasts of significant aviation weather parameters such as winds, visibility, and ceiling. The Laboratory is developing the ITWS algorithms that will utilize data from FAA and National Weather Service systems such as Doppler radars, surface weather stations, thermodynamic soundings downlinked from aircraft descending into air terminals, lightning mappers, and numerical forecast models. Technical support to the FAA is facilitating an aggressive program that will lead to an Initial Operating Capability (IOC) for ITWS in 1999, followed by algorithm refinements and additions supporting full capability by the year 2005. A formal demonstration of the IOC ITWS using Lincoln test beds is being conducted at Memphis, TN, and Orlando, FL, in 1994 in connection with the program full-scale deployment decision process.

ELECTRONIC DEVICES

Terahertz Continuous-Wave GaAs Photomixers
Radiation at terahertz frequencies has been generated by mixing two laser beams in a high-speed photoconductor fabricated from LTG GaAs. LTG GaAs is a unique material that exhibits a very short photoconductive lifetime, a high electrical breakdown voltage, and high photocarrier mobility compared to materials having a comparably short lifetime, making it very effective for generating high frequencies by photomixing. Photomixers have been fabricated consisting of interdigitated submicrometer-periodicity electrodes deposited on the top surface of an LTG-GaAs epitaxial layer. Such a device has been placed at the driving point of a self-complementary spiral antenna that radiates into free space through a silicon hyperhemispherical lens. The photomixer is pumped by two titanium: sapphire lasers, one of which is tunable in frequency by many terahertz. The photocurrent generated by the photomixer produces difference-frequency radiation that propagates through the lens into free space. The output power is nearly constant from 20 GHz out to about 300 GHz, in contrast to conventional electronic sources in this range that cover only 1 octave or less. The photomixer has generated continuous wave (CW) radiation up to 3.8 THz, the highest-frequency CW signal ever generated by electronic or opto-electronic means.

Free-Space Parallel Optical Interconnections Between Computer Components
A high-speed high-density parallel free-space optical interconnection technology based on compact and efficient opto-electronic components has been demonstrated. Compared with conventional electrical interconnections, the free-space optical approach offers greatly enhanced flexibility for dense and efficient transfer of digital information between circuit boards and multichip modules in high-performance electronic systems. The interconnections are implemented with compact transmitter and receiver...
modules capable of supporting 20 parallel optical data paths. The transmitter module contains a linear array of InGaAs diode lasers operating at a wavelength of 980 nm. The lasers have uniform low-threshold currents of several milliamperes and can be driven directly by ECL logic gates. The array pitch is 150 mm. The receiver module contains arrays of InGaAs photodiodes and GaAs heterostructure bipolar transistor amplifiers. Both modules incorporate photoformed glass microlens arrays to enable module separations of up to 1 cm. Testing performed at 2 Gbps indicates a bit error rate of less than $10^{-14}$ s$^{-1}$. The latency, or propagation, delay is as low as 170 ps and the crosstalk between channels is negligible. These results demonstrate a data-transfer capability of 300 Gbps/cm$^2$ with excellent signal integrity.

Devices for Ultrahigh Density Memory
Lincoln Laboratory has invented a new kind of phase-shifting lithographic technique to make dots half the size of those conventionally possible with any given optical exposure system. This technique has been applied to build 0.25-μm-diameter silicon cylinders, each containing either a transistor or a diode in series with an antifuse, forming the basic cell of a new type of memory. This once-programmable, read-only memory will take advantage of the very simple, primarily self-aligned bit structure to enable a storage density in excess of one billion bits per square centimeter.

Monolithic-Synchronous-Processor Element
The Synchronous Processor (SP) is a parallel computer architecture developed at Lincoln Laboratory over a period of 10 years under DoD sponsorship. The Laboratory has recently specified the design of a single monolithic integrated-circuit implementation of the SP processing element. These chips can be simply connected in an array to build a massively parallel computer called the Monolithic Synchronous Processor (MSP). The MSP provides high performance and low cost for a wide range of signal processing problems. Programs for the MSP may be written in standard ANSI C or C++ and can be developed independently from the hardware by using a software simulator running under OS/2.

The MSP chip is being produced under a Lincoln Laboratory contract to two commercial firms. It is unusual in this integration of a large amount of memory (4M bits), a powerful microprocessor (120 Mflop), and a high-bandwidth communication hardware on one chip. The first samples have been received, and it is anticipated that the chip will become commercially available in late 1994.

The construction of one or more 7-Gflop MSP parallel computers is under consideration. The purpose of these machines would be to develop a community of MSP users and to help the technical progress of computation-bound researchers.

COMPUTER BASED RECOGNITION TECHNOLOGY

Digital Architectures for Image Processing and Interpretation
Research is being done on multiprocessor computer architectures and related technology geared to processing and interpretation of synthetic-aperture radar, passive IR, laser radar, and visible imagery. High-speed free-space optical interconnects have been investigated for inter-processor communication and a demonstration ring network has been developed that transfers data between nodes at 6 Gbps by using six parallel free-space links. A scalable three-dimensional mesh architecture consisting of multiple layers of two-dimensional single-instruction multiple-data (SIMD) processor arrays is now being investigated as a potentially cost-effective system that can be easily scaled and reconfigured for different applications. Low-cost free-space electro-optical interconnects are being investigated as an alternative to wire interconnections between processor layers.

Spoken-Language Identification Using Parallel Multilingual Phoneme Sequence Analyses
Lincoln Laboratory has developed techniques for the automatic determination of language identity from conversational, telephone-quality speech based on language-independent phoneme recognition followed by statistical analysis of the resulting phoneme sequences. The system requires no textual or phonetic labeling of the training speech in the languages to be identified; thus, it can be quickly adapted to new languages. When tested in an evaluation administered by the National Institute of Standards and Technology (NIST), this system performed the best of all systems submitted over a wide variety of test conditions. Technology transfer to government sponsors is ongoing.

Neural-Network Wordspotter
Recent work has led to a high-performance hybrid neural-network/hidden-Markov-model system for wordspotting in continuous speech, which uses a new discriminant training algorithm called Figure of Merit training. This algorithm directly maximizes the detection rate of a wordspotter over a range of desired false-alarm rates. It eliminates the necessity of ad hoc thresholds and tuning and improved the average detection rate of wordspotters tested on a large corpus of spontaneous speech by roughly 5 percentage points to 70%. This new training algorithm resulted in a wordspotter with low computation and memory requirements that could be implemented in small portable computers. This system provided the best detection rate of any whole-word wordspotter we are aware of recently tested on the NIST credit-card speech corpus.
AIR DEFENSE TECHNOLOGY

Mountaintop Program
Adaptive jammer nulling techniques, in which antenna pattern nulls are adaptively placed in the directions of interferers, have been shown to be very effective in radar and communication applications. Lincoln Laboratory has been active in the area of satellite and radar adaptive-nulling technology for a number of years, most recently in the development of the fully adaptive Radar Surveillance Technology Experimental Radar (RSTER), which was tested and demonstrated at Wallops Island in 1992. Significant current work in this area is focused on airborne surveillance radar applications. The ability of airborne radar to detect small moving targets can be degraded by jamming and by ground clutter (which has apparent motion due to the airborne platform's velocity). The adaptive processing concept can be extended to modify dynamically an airborne radar's response in both spatial and Doppler domains (space-time), such that mitigation can be provided against both jamming and clutter.

Airborne testing, evaluation, and data gathering inevitably involve considerable expense. Therefore, the ARPA Mountaintop Program is seeking to develop the techniques and technology of space-time processing at mountaintop test sites, which can simulate an airborne geometry, before the costs associated with a flight test program are incurred. The RSTER has been modified as an instrumentation sensor and has been installed at North Oscura Peak at WSMR to support space-time adaptive algorithm testing and ground-reflected jamming phenomenology. Additional experiments at the WSMR test site against targets of opportunity have focused on characterizing the radar signatures of tactical ballistic missile plumes. The radar is being moved to a new mountaintop test site on the island of Kauai, HI, in the summer of 1994, to support further airborne-radar technology testing over the sea surface.

Airborne Seeker Test Bed
The capabilities of modern air defense missile seekers have been severely challenged by the advent of low-observable vehicles and modern electronic countermeasures. The Airborne Seeker Test Bed is an instrumentation platform developed by Lincoln Laboratory that carries a variety of instrumented seekers with advanced capabilities to investigate these challenges and identify appropriate seeker architectures and signal processing algorithms for dealing with them.

In response to the increased demand for adding sensor payloads, the Seeker Test Bed is being upgraded to give it more support capabilities for special-purpose pod sensors. A total of five pods can be carried, with sensor slaving and data recording services provided in the cabin. One such pod currently under development at the Laboratory is a two-color infrared high-resolution focal-plane-array instrumentation sensor for supporting investigation of IR seeker performance, countermeasures, and signal processing issues. This pod included hardware features for exploring various techniques to compensate for focal-plane pixel-to-pixel nonuniformity, a characteristic that can severely limit the target-detection performance of focal-plane-array sensors.

Analog Fiber-Optic Links
Lincoln Laboratory has been extending the technology of optical fiber links, so prevalent in digital networks, to accommodate the special requirements of analog links. These analog links are expected to enable a variety of military and commercial applications such as antenna remoting and cable TV distribution. The principal link issues that need to be addressed are lower noise figure and increased intermodulation-free dynamic range. Improvements in these link parameters have been pursued by using two methods at Lincoln Laboratory, one of which has the RF signal directly modulate the laser intensity and the other of which imposes the RF modulation by using a modulator connected to the output of a CW laser. The Laboratory research has produced the lowest noise figures to date for both modulation methods with the lower noise figure having been obtained by using external modulation.

The RF performance of analog links can currently meet the needs of technology-driven applications in which cost is a secondary consideration. However, the potential exists for a much broader range of applications that are precluded at present by the high cost of packaging the electro-optic components. To address these applications Lincoln Laboratory was asked to join an ARPA-funded consortium whose focus is the development of low-cost analog opto-electronic components. The Hughes Research Laboratory will be leading an eight-member team on a two-year effort to reduce by an order of magnitude the cost of electro-optic components for analog links.

STRATEGIC DEFENSE TECHNOLOGY

Measurement Range Integration
Lincoln Laboratory provides the scientific direction for all data-collection sensors at the Kwajalein Missile Range in the Marshall Islands. A major project currently under way is to provide a common control center, the Kwajalein Missile Range Control Center (KMRCC). The initial phase of the effort became operational in FY93, and provides range control functions as well as pointing control for telemetry and optics. At present, the sensor control is being enhanced by incorporating radar data fusion capability and automated target-handling functions. Other projects are under way to expand the bandwidth of the millimeter instrumentation radar to 2 GHz, and to enhance the waveform generation and signal processing capability of the ALTAIR radar.
Lexington Discrimination System (LDS)
The hardware and software upgrades to the real-time test bed allow the evaluation of multi-object/multi-sensor automatic-target-recognition procedures. Specific problem areas critical to the TMD problem area are being examined by using LDS. Application packages are developed, prototyped, and tested on the LDS prior to installation in a field sensor or system, thereby accelerating the schedule and reducing the risk.

The test bed is a general-purpose resource capable of supporting a wide variety of tasks. The LDS host supercomputer has a high-speed playback unit, large random-access memory, and real-time operating system based in the UNIX environment. It can support applications that are computationally intensive, that require fast access to a massive data base, or that fuse and process multiple data streams.

WALTER E. MORROW, JR.
The established fields of Architecture and of Urban Planning are currently going through a period of rethinking and reformulation, and the emergent field of Media Arts and Sciences is growing and changing at a fast pace. In response to the challenges presented by these conditions, the School of Architecture and Planning has, during the 1993-94 academic year, vigorously continued ongoing processes of faculty building and renewal, ambitious facility rebuilding, development of computer and digital telecommunication capabilities, and initiation of new research and curricular ventures. These efforts are expected to position the School as a strong leader into the 21st century.

Faculty

Faculty development and renewal remains a top priority. During 1993-94 there were important faculty appointments in all units of the School.

The Department of Architecture made significant steps in development of the Design and Computation area by appointing Julie Dorsey and Takehiko Nagakura to Assistant Professor positions, and by completing an extensive search for a senior appointee in this area as well. Attilio Petruccioli was appointed as Aga Khan Professor, filling a vacancy that had existed since the departure of Professor Ron Lewcock. Searches continued in the area of Building Technology and for a senior designer to provide leadership in the studios; these efforts are expected to come to fruition in 1994-95. In Visual Arts, Professor Krzysztof Wodiczko was promoted to tenure.

In the Department of Urban Studies and Planning (DUSP), additional senior leadership was provided with the appointment of Alice Amsden as Ellen Swallow Richards Professor.

In Media Arts and Sciences (MAS) there was a leadership transition as Professor Steve Benton completed a superb term of service as Section Head, and Professor Whitman Richards moved from Brain and Cognitive Sciences to take over the position. Ted Adelson, who had been Associate Professor without tenure in Media Arts and Sciences, moved to a tenured position in Brain and Cognitive Sciences but retained a secondary appointment in MAS. The death of Professor Muriel Cooper created a huge void in the Visible Language Workshop, and recruitment of a strong replacement is a very high priority.

In the Center for Real Estate, Blake Eagle took over as Director. We were fortunate to retain the valued services of former Director Tom Steele, who launched an ambitious effort to initiate research and teaching on real estate and related issues in China. A major gap was filled when Timothy Riddiough was appointed as Associate Professor to fill a position in Real Estate Finance.

At the end of the academic year, Professor Otto Piene became Director Emeritus of the Center for Advanced Visual Studies, with the expectation that the search for a new Director would be completed during the summer.

During the year, news came of the deaths of former Deans Lawrence B. Anderson and Pietro Belluschi. The memorial gatherings were attended by many distinguished alumni and former faculty of the School.

An overall result of faculty changes in the last two years has been a significant alteration in the profile. We now have a substantially younger faculty, and efforts to recruit women and underrepresented minorities are beginning to pay off.

Space

Many of the School's activities continue to be housed in inadequate and inappropriately located space, but the year saw important progress in the ongoing major effort to consolidate the School's space in contiguous locations and to create facilities of the necessary high quality to support research and teaching.
in the 21st century. The Dean's Office moved into newly renovated space in Building 7. An exciting master plan for moving Architecture studios and faculty offices back to the Main Complex was developed by the firm of Leers, Weinzapfel Associates, architectural work on the first phase was completed, and demolition and construction began in Summer 1994. The first phase of this construction included design studio space in Building 5, Building Technology faculty office and laboratory space in Buildings 5 and 3, and Architecture faculty offices in Building 10. Occupancy of this newly renovated space is expected in Spring 1995.

Major efforts were devoted to raising funding needed for these and further space renovations and for equipping the new studios with advanced computing and telecommunications capabilities.

**Educational Initiatives**

Curricula throughout the School continue to evolve vigorously in response to emerging conditions and opportunities.

The Department of Architecture continued successfully with phased introduction of its newly redesigned curriculum for the M.Arch. first professional degree program. This curriculum strengthens design studio teaching, introduces computer technology at an early point in a systematic way, and generally provides a more rigorously organized sequence of study for students preparing for professional careers as architects.

Media Arts and Sciences proceeded further with its explorations of potential undergraduate offerings. As a first step towards an expanded role in undergraduate education, a new introductory subject in Media Arts and Sciences was introduced with great success. The report of the Academic Review Committee (which was set up by the Provost to evaluate progress and consider future directions for MAS) was released; it praised achievements—particularly in research—and suggested that identification of a stable intellectual core was a next step towards a greater undergraduate role for MAS.

In the Visual Arts, a new graduate program in Public Art was initiated, and the first students were admitted for 1994-95. The Center for Advanced Visual Studies ended a transitional year with a major retrospective exhibit; the coming year will be one of setting new directions for the future.

The Aga Khan Program for Islamic Architecture entered a period of reevaluation and consideration of possible future directions as funding became increasingly scarce. His Highness the Aga Khan was the Institute's Commencement speaker in June, and this provided an occasion to strengthen his relationships with the School and the Institute and to begin evaluating future directions.

**Public Outreach**

During 1993-94 there were some important new initiatives aimed at broadening awareness of the School among potential students and supporters and at creating public dialogue on important issues. An effort to consolidate and focus the School's publication program was commenced, and the School's flagship publication *Plan* was redesigned for the start of the 1994-5 year. The School was particularly strongly represented at Tech Day, where distinguished graduate I. M. Pei spoke to a large audience in Kresge Auditorium on his major redesign of the Louvre.

A particular highlight of the year was the Boston Conference, organized by DUSP in conjunction with Harvard's Kennedy School. This considered ideas for the future of the Boston region, and attracted wide participation from prominent politicians, community leaders, and scholars. It culminated in a televised public event and production of a special color supplement in the *Boston Globe*.

**Visiting Committees**

A new structure has been initiated for the School's Visiting Committees; instead of just one committee for the whole School, there is now one for Architecture and MAS, and another for DUSP. This year saw
visits from both of the new committees. The Architecture/MAS Visiting Committee had particularly high praise for the vigorous research and educational initiatives of the Media Laboratory and MAS.

Awards

The Ralph Adams Cram Award for outstanding interdisciplinary work at the Master's level was presented to Lavea Brachman; the Lawrence B. Anderson Award for an alumni research project went to Daniel Abramson.

Summary

The 1993-94 academic year was an exciting one for the School of Architecture and Planning as key faculty appointments were made, as efforts to rebuild the School's space moved forward, and as new subjects and curricula were initiated. Its forward progress is rapidly gathering momentum.

William J. Mitchell
In the summer of 1993 the Department of Architecture received the report from the National Architectural Accreditation Board (NAAB) visit of the previous spring. Generally very positive, the NAAB gave MIT the maximum five-year renewal of accreditation. The problems noted were ones that had been previously identified, and thus we can already report progress on their resolution.

**Master of Architecture (M.Arch.) thesis** (criticized as being uneven, and generally weaker than other student work). The new curriculum which began to be phased in this year is designed to prepare students for thesis work earlier and more thoroughly. Additionally, efficient action by the faculty, with the particular effort of Assistant Professor Ellen Dunham-Jones has led to improved thesis preparation and theses also for the students now completing under the old curriculum.

**Computation and architecture** (our department was judged deficient by any standard, and all the more surprisingly so given the context of MIT). We had begun working on this issue in consultation with William Mitchell prior to his consideration as Dean. With Mitchell's arrival at MIT, development has been rapid. In 1993-94, Mitchell took charge of the fundamental teaching in the area and guides development of facilities and research. New appointments will bring the leading theoretician in the field, George Stiny of UCLA, and two talented young people, Julie Dorsey of the University of Pennsylvania and Takehiko Nagakura, completing his Ph.D. at Harvard. MIT should quickly move to the top rank in this discipline which will also build bridges to other departments.

**Minority student representation.** In this year's acceptances, five of 30 M.Arch. and four of 21 S.M. students are from minority groups (4 Hispanic, 4 African-American, 1 Native American).

Other achievements are noted in the Highlights below, but it must be acknowledged that numerous problems continue to arise.

**Architecture design faculty.** This year we enjoyed the successful integration of three new tenure-track design faculty, but the search for a key senior professor was not completed.

**Building technology faculty.** This discipline group is in need of rebuilding, yet searches were not concluded.

**History, theory and criticism faculty.** Long a strong group within the department, HTC now needs attention and faculty rebuilding. The young faculty recruited some years ago, while exemplary in their teaching, have been slow or failing in completion of doctoral degrees. This in turn has led to an excess of leaves with attendant loss of attention to graduate students and administration.

**Visual arts faculty.** The granting of tenure to Associate Professor Krzysztof Wodiczko is key to the rebuilding of this program, but it will now face difficult tasks in assuming direction of the Center for Advanced Visual Studies, implementing a new graduate program, and seeking another artist for the faculty.

**Aga Khan Program.** A significant part of this program has run on current funds from the Aga Khan Trust which will now be sharply curtailed.

**Space/Facility renovation.** In itself a very positive long-term effort, the facility renovation that is about to begin will, until completion of later stages, present its own difficulties for organization and teaching.

**Administration.** The department reorganized its administration one year ago. Now a mandated change, significantly cutting budget, forces a second reorganization in two years.

**ADMISSIONS/STUDENT AID.** The most serious problem we face is student aid. This year it has become very clear that we are not winning the best students for any of our degree programs and that the principal cause is our unfavorable tuition/student aid situation.
PROGRAM ENROLLMENTS AND STUDENT AWARDS

Enrollment. A total of 85 undergraduates and 185 graduate students (including 98 M.Arch., 41 S.M.Arch.S./S.M. without specification, 10 S.M.B.T., 17 Ph.D. resident and 15 Ph.D. non-resident, and 4 nondegree special students) were counted in Course IV this year.

New curriculum. The first 12 graduate students admitted to the revised M.Arch. curriculum entered in September. Shun Kanda took responsibility for teaching the first studio for this group. The students have completed the first two terms of the three semester core and are off to a strong start.

Department awards. Chamberlain Prize for graduating B.S.A.D.s for achievement in design (Michelle Kim, Victoria Parson). Karofsky '37 Prize for the outstanding Master of Architecture student with one further year of study (Shaun Roth). Chandler Prize for achievement in architectural design (Paul Matelic, June Williamson). Alpha Rho Chi Medal for leadership, service for the school and department, and promise of real professional merit (June Williamson). AIA Certificate of Merit for second-ranked master of architecture student (Gregory Iboshi). AIA Medal for the top-ranked master of architecture student (Lillian Sung). S.M.Arch.S. Prize (Jack DeBartolo III, Jeffrey Holmes, Panayiota Pyla). Halasz Thesis Award, given for the first time this year (Ron Eng). AIA Foundation Scholarship nominees (Anthony Montalto, Matthew O'Connell, Erik Mar).

HIGHLIGHTS OF THE PAST YEAR

Promotions and retirements. Tenure was granted to Associate Professor Wodiczko of the Visual Arts Program. Professors Sandra Howell and Eric Dluhosch retired during this year, but will continue to contribute to the department through part-time teaching and advising. Assistant Professor Rosemary Grimshaw leaves the department's studio faculty at the end of this year.

New graduate program. A graduate program in Public Art, organized by Professors Edward Levine and Wodiczko, was approved and the first two students were admitted to the program for fall 1994.

Studios here and abroad. Studio teaching continued to take advantage of opportunities to involve students and faculty in projects outside of Cambridge, and even abroad. Sites included Puerto Rico, Pakistan (a workshop combining students and faculty in building technology and design), Mexico, Texas, and Florida. The department will study the value of these experiences measured against the cost of time spent away from the school.

Lecture Series. James Ingo Freed gave the Arthur Schein Memorial Lecture and Sverre Fehn gave the first Pietro Belluschi Lecture. The Architecture Lecture Series brought Carol Johnson, Benjamin Buchloh, Aldo van Eyck, Thomas Hanrahan and Victoria Meyers, Vittorio Gregotti and Craig Barton in the fall. In the spring speakers included Jane Thompson, Colin St.John Wilson, Dietmar Steiner, Diane Ghirardo, and Wellington Reiter.

New faculty and visitors. Attilio Petruccioli joined the faculty as Aga Khan Professor of Architecture for Islamic Societies. New junior faculty members, Assistant Professors Dunham-Jones and Ann Pendleton-Jullian and Associate Professor Andrew Scott, completed their first year. Visiting faculty included Bruno Pfister, Jim Glymph, Steven Imrich, Royston Landau, Henry Millon, Akos Moravánszky, Thierry de Duve, Howyda Al-Harithy, Mina Marefat, Yule Heibel, Takehiko Nagakura, Geraldine Erman and Michael Byron.

MIT Visiting Committee. The Visiting Committee, chaired by Alexander Dreyfoos, was divided in two subcommittees. The Architecture Subcommittee (Ann Beha, Thomas Cabot, Joseph Esherick, M. David Lee, John Morefield (subcommittee chair), Elizabeth Plater-Zyberk) spent two days in the department meeting with students, faculty and administration. In general, the subcommittee was receptive to the progress and goals of the department.

Exhibits. An ambitious exhibit, organized by Professor Jan Wampler, students and faculty made visible a view of the philosophy and objectives of the department through the work of its students, faculty and alumni/ae. The exhibit was dedicated to the memory of Dean Emeritus Lawrence B. Anderson. President Vest accepted an
invitation to view the exhibit and an accompanying slide presentation. Fernando Domeyko organized topical exhibits throughout the year, including the work of Aldo van Eyck and Spanish architects Ortiz, Barrionuevo and Cruz. An exhibit of work by a Level III studio stood in Lobby 10 during the Technology Day activities which featured the arts and architecture at MIT.

Publications. The department publication Thresholds continued its mission with four topical issues, which were distributed to alumni/ae as well as to the department. Student initiative led to the publication of a weekly newsletter, PIN UP, beginning in the spring term and featuring opinions and articles, reviews of lectures and exhibits, calendar items, photos and drawings, and doses of humour.

Conferences. Assistant Professor Sibel Bozdogan organized a four-day conference, "Re-thinking the Project of Modernity in Turkey," funded by the Aga Khan Program for Islamic Architecture at Harvard and MIT. Associate Professor Leslie Norford hosted the annual IEA Annex 25 Building Optimization and Fault Detector meeting, charged with developing advanced techniques for minimizing energy consumption in building HVAC systems.

Faculty research, publications, exhibitions and awards. Research in the department is advanced through many means: conferences such as those mentioned above and others attended by faculty and students (including but not limited to the Association of Collegiate Schools of Architecture, US National Conference on Wind Engineering, College Art Association, Middle East Studies Association, and the Society of Architectural Historians), workshops such as the housing design and technology workshop for Northern Pakistan, and collaboration with visitors and other institutions. The Building Technology Group has undertaken to collaborate with four Swedish Universities to conduct research on energy efficient buildings. Associate Professor Wodiczko participated in an exhibition at the Museum of Fine Arts, Boston. In addition, he worked on artistic projects in Paris, Warsaw, Barcelona and Helsinki. The office of Professor Michael Dennis received a Progressive Architecture Award for the University of Southern California campus plan. The Gyorgy Kepes Prize this year went to Assistant Professor Wellington Reiter. Mr. Domeyko received a Graduate Teaching Award from MIT's Graduate Student Council. Upon receiving both a Guggenheim Fellowship in Sculpture and a Bunting Fellowship, Assistant Professor Ritsuko Taho was on leave this year working on large and small scale projects in the US and in Japan. HTC faculty members published widely during the year. Assistant Professor Nasser Rabbat has been on leave this year, his scholarly work supported by a Getty post doctoral fellowship. Assistant Professor Bozdogan was named to the Ford International Career Development Professorship and will take leave in the coming academic year supported by the chair and a Provost's grant. In addition, she received a grant from the Near and Middle East Program of the Social Science Research Council.

Losses. The department, its friends and alumni/ae, were deeply saddened by the deaths of Pietro Belluschi (Dean, 1951-1965) and Lawrence B. Anderson (Department Head, 1947-1965; Dean 1965-1972). Memorial events were held in their honor.

STANFORD ANDERSON
With the completion of an MIT-internal review of our academic program and aspirations last summer, we continue our planning toward more significant participation in the undergraduate educational experience at MIT. While further consideration of departmental status properly awaits the evolution of a more stable intellectual core for a Media Arts and Sciences (MAS) curriculum, the review process has prompted our faculty to consider joint degree programs with other departments, and other paths toward undergraduate programs that emphasize an apprenticeship-mode or atelier experience.

Our flagship undergraduate offering, entitled "Bits are Bits," was organized by Professors Nicholas Negroponte and Michael Hawley and presented for the first time this Spring. Almost one hundred students completed the subject, with roughly equal numbers from each undergraduate class.

After seven years of guiding the development of the MAS academic programs, our founding Program Head, Professor Stephen A. Benton, is turning over those responsibilities to a new member of our faculty, Professor Whitman A. Richards. Prof. Richards has been a member of the MIT faculty since 1965, in the Department of Brain and Cognitive Sciences. He brings considerable experience in education at all levels to the Program in Media Arts and Sciences.

**EDUCATION:**

**Graduate:**

One hundred and eighty-four applications for our graduate program were received this year, from which 37 were selected for admission (including seven women and one underrepresented minority) – 32 for the Master's program, and 5 for the Doctoral program. Our graduate student population this year consisted of 99 students (19 women and four underrepresented minorities, and 23 foreign students), of whom 56 were in the Master's program and 43 in the Doctoral program. Twenty-four advanced degrees were awarded during the year (18 S.M. and six Ph.D.). Thirty-one graduate subjects were offered by the Program this year.

**Undergraduate:**

This year we offered nine undergraduate subjects. While MAS lacks an official undergraduate academic program, the number of UROP students active in the Media Laboratory has continued to grow, to 202 this year, dramatically increasing our lively interaction with the undergraduate student body. Of these students, many pursue their undergraduate thesis research under our faculty’s supervision. Five of the MAS faculty and Media Lab staff conducted freshman advising seminars or served as freshman advisors this year.

**FACULTY AND STAFF:**

**Tenure:**

Associate Professor Edward H. Adelson was appointed a permanent member of the MIT faculty. Prof. Adelson’s interests include human vision and image processing. Professor Adelson is jointly appointed in the Department of Brain and Cognitive Sciences and the Program in Media Arts and Sciences.

**New Appointments:**

Our faculty recruiting program has gained momentum with a renewed search for four new junior faculty, responding to the challenge of increased undergraduate teaching within the Program.

Dr. Michael J. Hawley was appointed X-Consortium Assistant Professor of Computer Science and Media Technology at the beginning of the year, jointly with the Department of Electrical Engineering and Computer Science. Prof. Hawley received his Ph.D. in Media Arts and Sciences from the Program in Media Arts and Sciences, MIT, in June, 1993. His interests include networked information services, and "information appliances" for the home environment.

**Honors and Awards to Faculty and Students:**

Professor Mitchel Resnick received an NSF Young Investigator Award.

Two projects by faculty and students won coveted Honorable Mentions at this year’s Ars Electronica at Linz, Austria: Professors Pattie Maes and Alex Pentland, with graduate students Bruce Blumberg and Trevor Darrell, for “ALIVE: An artificial life interactive video environment,” and Eddie Elliott for “Video Streamer” (a tool for interactive video production developed for his S.M. thesis).

Finally, we report with sadness the death of Muriel Ruth Cooper, Professor of Interactive Media Design, on May 26, 1994. A founding member of the Media Laboratory and a wise counselor in guiding our academic evolution, Prof. Cooper was in many ways just reaching the fullest expression of her computational design genius.

STEPHEN A. BENTON
INTRODUCTION
The past year was marked by progress on three important goals:

- enhancing research and teaching on effective practice;
- expanding the undergraduate program; and
- developing depth with the hiring of new junior faculty.

At the same time, our graduate degree programs continued to attract a diverse group of top-caliber students and our faculty made outstanding contributions to the many arenas which comprise the planning profession.

RESEARCH AND TEACHING ON EFFECTIVE PRACTICE
Strengthening links between academic research and teaching on the one hand—and planning practice on the other—is at the top of the department’s agenda. Faculty are innovative in their abilities to develop projects which add to the body of knowledge about effective practice and involve students in real-life applications of planning tools and ideas. The Department of Urban Studies and Planning (DUSP) faculty may be found working on projects all over the globe. For example, Professor Lawrence Susskind developed a Sustainable Development Curriculum for the Dutch government which will be used for an annual international seminar in Amsterdam. Professor Karen Polenske conducted research funded by the National Science Foundation on declining energy intensity in China.

Here in the United States, Professor Bernard Frieden explored possibilities for redevelopment of military bases in US cities. Lois Craig, Professor Joseph Ferreira, Professor Frieden, Michael Shiffer and Professor Mark Schuster examined issues in metropolitan planning and development in the year 2050, sponsored by the National Capital Planning Council (NCPC). Both undergraduate and graduate students participated in the project by completing class assignments that utilized geographic information systems (GIS) to address land-use planning issues concerning the NCPC.

Closer to home, Professor Lawrence Vale evaluated public housing redevelopment efforts in Boston. Lois Craig planned an exhibition for the MIT Museum, which will capture the dramatic physical change in Boston over the past 40 years. This is part of a broader documentary study that will culminate in an interactive historical atlas of the city of Boston.

Teaming up with colleagues from other departments or centers at MIT for joint projects was also a hallmark of this year’s research agenda. Professor Polenske collaborated with colleagues at the Sloan School on the Ningbo, China Investment Strategy project and the Center for Transportation Studies’ research on the effects of the federal Clean Air Act on transit in Boston.

Planning for the future of metropolitan Miami, Florida was the focus of a joint studio with the Department of Architecture. DUSP Professor Gary Hack and Antonio DiMambro contributed innovative ideas to the Metro-Miami Marketplace 2001 committee, recommending new ways to think about airport and seaport expansion, as well as commercial development.

Professor Frank Levy’s Workshop on the Massachusetts Economy sponsored a joint studio with the Industrial Performance Center on economic development. The Space Planning Organization Research Group (SPORG), which includes Turid Horgen, Michael Joroff and Professor Donald Schon, has been looking at two questions: 1) How to make better workplaces by integrating spatial, technological and organizational dimensions; and 2) How a workplace gets developed, from the programming, designing and building stage to the maintaining and managing stage.

UNDERGRADUATE PROGRAM
Once again this year, we expanded our undergraduate course offerings to reflect the growing interest in our field among undergraduates. A year ago we reported 296 enrollees in our courses and 15 majors. This year we had 373 enrollees and 21 majors. Our Undergraduate Research Opportunities Program (UROP) enrollment continued to increase. The growing number of undergraduates in an overwhelmingly graduate program challenges us to find new ways to serve the special needs of undergraduates. Our immediate goal is to expand course offerings in the international area.

FACULTY DEVELOPMENT
We welcomed three new junior faculty members this year, adding depth and breadth to our ranks. All three had busy first years, balancing their teaching with their research and practice.

Professor Kristina Hill organized a workshop in eastern Germany on the future of coal mining regions and ecological reclamation efforts, in cooperation with the Technical University of Dresden and the Minister of the Environment. She also consulted to design studios sponsored by the Department of Architecture for Dallas, Texas on sustainability, water use and suburban development and San Juan, Puerto Rico on redevelopment of a commercial strip.
Working on a project with faculty in the Department of Civil and Environmental Engineering on managing chlorine in the environment, Professor Vicki Norberg-Bohm has been focusing on policies for green innovation.

Professor Qing Shen's non-teaching time has been spent working on a project with colleagues at the University of California at Berkeley on using geographic information systems (GIS) in transportation planning and growth management.

FACULTY ACHIEVEMENTS
Among the many achievements of the faculty, including outstanding teaching, exemplary practice, and prolific publication, several stand out for receiving special awards, appointment to new positions or publishing books. Dennis Frenchman won the American Institute of Architects Award for Planning Excellence for his "Back to the Beaches: Plan for the Boston Harbor Beaches." Among those with new positions, Professor Frieden was appointed Associate Dean of the School of Architecture and Planning; and Professor Langley Keyes now holds the Ford chair for City and Regional Planning. Professor Levy was awarded a grant from the A.P. Sloan Foundation to study the growth of occupations suitable for apprenticeship programs. Professor Polenske was named in Who's Who in America. Professor Bishwapriya Sanyal spent his sabbatical on a visiting fellowship to the East-West Center in Honolulu, Hawaii and a research fellowship at the Center for Development Research in Copenhagen, Denmark. A new edition of Professor Susskind’s book Breaking the Impasse: Consensual Approaches to Resolving Public Disputes (with Jeffrey Cruikshank), was published in Chinese. Two of his other books published this year were Environmental Diplomacy: Negotiating More Effective Global Agreements and International Environmental Negotiation, Volume 3, (with William Moomaw and Adil Najam). Professor Judith Tendler received a grant to write a book on good government in the tropics. Professor Vale won the Spiro Kostof Award from the Society of Architectural Historians for his book Architecture, Power, and National Identity.

Nearly 100 people braved a February snow storm to attend a symposium entitled "Reflecting on Don Schon’s Practice," honoring retiring Professor Schon and his contributions to the department over the last 26 years. Schon remains a member of the faculty as Professor Emeritus and Senior Lecturer.

Another long-time member of the faculty, Adjunct Professor Philip Herr, also retired at the end of the school year. An event to pay tribute to his accomplishments over the last 25 years will be held in the fall.

Louise Dunlap and Richard Schramm also left the faculty after many years of outstanding contributions to the teaching program.

GRADUATE DEGREE PROGRAM ACTIVITIES
Both the Master's and Ph.D. programs have maintained steady enrollment in the last couple of years. This year, the student body was more than fifty percent women, fourteen percent people of color and thirty-four percent international students. The department awarded 47 Master's degrees and seven Ph.D.s.

The annual commencement breakfast included presentation of awards to three Master's students. Karen Lado received the American Institute of Certified Planners Outstanding Student Award. A paper written by Kimberly Tall Bear won the Flora Crockett Stephenson Writing Prize. J. Christoph Panfil received the fourth annual Wallace, Floyd Award for Urban Design. In addition, Ph.D. students Nicolas Rockier and Michael Stoll won dissertation research grants from the Department of Housing and Urban Development (HUD).

SPECIAL EVENTS AND PROGRAMS
In the spring, MIT co-convened—with Harvard University and the Boston Globe—the Boston Conference: Shaping the Accessible Region. MIT's involvement was a cooperative effort among DUSP, the department of Civil and Environmental Engineering and the Region 1 University Transportation Center. DUSP Professors Clay, Gakenheimer, Hack and Porter, assisted by four graduate students, conducted research in preparation for the conference, which was directed by Tom Piper.

At two public forums in April—attended by 900 opinion leaders from the Greater Boston area—fifteen local panelists testified before a national jury of experts in the fields of economics, the environment, urban design, transportation and government. One month later, the national jury presented its recommendations for transportation and economic development options for Greater Boston at the beginning of the 21st century to a panel of representatives from the White House, the State House and Boston City Hall. One product of the conference will be a 40-page, non-advertising, special supplement to the Boston Sunday Globe in October of 1994. Another will be the release of the Globe text and video from the forums on a CD-ROM disk.

Seventeen mid-career professionals came from around the globe to participate in the Special Program for Urban and Regional Studies (SPURS) this year. Not only was this the largest group of SPURS Fellows ever, but ten of this year's Fellows were women—a significant increase from previous years—and, for the first time, six came from the former Soviet Republics.
Somewhat of a domestic counterpart to the SPURS program, the Community Fellows program brought together thirteen mid-career community activists from communities of color in the US to build skills to develop youth-oriented programs for their home communities.

Our Professional Development programs continued to meet the needs of students and alumni/ae alike. The Internship Program places Master’s students in a variety of professional settings—often supervised by alumni/ae—to work on projects relevant to their academic interests. Despite the harsh weather, the annual Professional Development Institute—26 workshops and short courses held over six weeks in January and February (many of which were listed in the Independent Activities Period [IAP] Guide)—was well attended by students, alumni/ae and other professionals.

Phillip L. Clay
The Aga Khan Program for Islamic Architecture (AKPIA), established in 1979, functions jointly at MIT and Harvard University to promote research and teaching concerning architecture and urbanism in countries with Islamic societies. Generous gifts from His Highness the Aga Khan support the AKPIA through endowed funds that provide for faculty, student financial aid, library facilities, and research; annually received current funding also supports teaching and student financial aid, in addition to publications, documentation, student travel, and outreach activities. The central office, located at MIT, serves as a continuous liaison for activities at both universities; coordinates joint, program-wide activities; maintains a steady exchange of fiscal and substantive information between the program and the donor; and coordinates program outreach in the Muslim World.

This May, His Highness Prince Karim Aga Khan IV was the invited speaker at the Institute's 128th commencement. During his visit to MIT, he met with Presidents Vest and Rudenstine of MIT and Harvard University respectively to discuss the future of the Aga Khan Program. He also attended presentations by the AKPIA 1993–94 Outreach and Research grant recipients on the following projects: "Karimabad Design Research Project," "Cairo Park," "Library Resource Development Project," "Mostar 2004: an international workshop to be held in Istanbul, July 25–August 25, 1994," "Rethinking the Project of Modernity in Turkey," "Real Estate Holding Companies," "Simulating the Thermal Performance of Pakistani Building Materials: A Prerequisite to a Demonstration Building." He also met with the AKPIA Committee after which a reception in his honor was held in the Emma Rogers Room.

During the 1993–94 academic year, the central office continued its communications and outreach work for the program. Internal communication between and among students, faculty, staff, and the Harvard and MIT communities functioned through the AKPIA monthly calendar and announcement listings that together alerted the community of program activities and resources, staff travel, program meetings, and special events. The central office also compiled and distributed periodic listings of grant and scholarship opportunities pertaining to the interests of AKPIA students. The sixth volume of a program-wide newsletter, which reports on the program's many activities, was produced and distributed to the AKPIA community, interested scholars, professionals, and institutions at home and abroad. "Architecture, Culture and Technology," a lecture series sponsored by the Program and organized by AKP visiting professor Mina Marefat, included distinguished architects Jean-Louis Cohen, Kenneth Frampton, Jörg Sierig, James Cramer, Nader Ardalan, Marco Brambilla, and Aga Khan Professor Attilio Petruccioli. Other lectures included one on Vijayanagara by John Fritz and George Michell, and lectures by AKPIA visiting scholars Madhavi Desai on the traditional houseform of Bohras in Gujarat, India, and Amir Pasic on the destruction and planned rebuilding of Mostar in Bosnia-Herzegovina. As part of the AKPIA's Parallel Centers program of international outreach, graduate studies enrichment and development continued at both the University of Jordan in Amman and the Dawood College of Engineering and Technology in Karachi, Pakistan.

FACULTY
The AKPIA Committee, charged with policy decisions during the 1991–94 cycle, included Stanford Anderson, head, Department of Architecture, MIT (chair); Barbro Ek, director, AKPIA (ex officio); William A. Graham, director, Center for Middle Eastern Studies, Harvard; Philip S. Khoury, dean, School of Humanities and Social Sciences, MIT; William Mitchell, dean, School of Architecture and Planning, MIT; Gülru Necipoğlu, John L. Loeb Associate Professor of the Humanities, Harvard (on leave); Attilio Petruccioli, the newly appointed Aga Khan Professor, MIT; William L. Porter, Leventhal Professor of Architecture and Planning, MIT; Nasser Rabbat, Aga Khan Development Professor, History, Theory and Criticism Program in the Department of Architecture, MIT (on leave); and Christoph Wolff, dean, Graduate School of Arts and Sciences, Harvard. AKPIA Operational Committee members included Sibel Bozdogan, Assistant Professor of Architecture, MIT; András Riedlmayer, Aga Khan Program Bibliographer, Harvard; and Irene Winter, chair, Department of Fine Arts, Harvard; in addition to Barbro Ek, Attilio Petruccioli, William Porter, and Nasser Rabbat.

In February, Italian architect Attilio Petruccioli joined the MIT architecture faculty as the Aga Khan Associate Professor of Islamic Architecture and head of the AKPIA SMArchS Concentration in Architectural Studies of the Islamic World (formerly Design for Islamic Societies) allowing Professor William Porter to step down from the position of acting head. Professor Petruccioli is the founder and president of the Islamic Environmental Research Center in Como, Italy, and chief editor of the journal Environmental Design. In the spring, he taught "Typological Process and Built Form," a method and theory-oriented course introducing students to more advanced study of urban form to be explored in future studios that he will be teaching over the next two and a half years.
Assistant Professor in the History of Islamic Architecture Nasser Rabbat was on leave this year working both on turning his dissertation into a book and researching a project on the militarization of architectural expression in the medieval Middle East. Two visiting professors, Howyda Al-Harithy and Mina Marefat, taught Islamic architectural history courses within the History, Theory and Criticism section of the Department of Architecture in his absence.

ACADEMIC PROGRAMS AT MIT

Concentration in Architectural Studies of the Islamic World component of the SMArchS program

This year, three new AKPIA students participated in the Concentration in Architectural Studies of the Islamic World component of the Master of Science in Architecture Studies (SMArchS) degree program. With eight continuing students, the unit accommodated eleven SMArchS students. In addition, one MArch and one MA student participated in the AKPIA Concentration in Architectural Studies of the Islamic World.

Student reflection and debate focused on both practical and theoretical issues concerning the architecture characteristic of non-western societies. Students were encouraged to compare traditional Islamic architectural forms and structures with those developed after the spread and application of Western ideas in modern times. They considered appropriate responses to climate, building materials, and building technology as well as the socio-cultural attitudes and values that directly relate inhabitants to their environment.

Several courses were devoted to specific problems currently faced by the Northern Areas of Pakistan as part of collaborative efforts between the AKPIA, the Karimabad Planning Support Service (KPSS), the Aga Khan Cultural Services, the Aga Khan Housing Board in Pakistan, and the Aga Khan Trust for Culture’s Historic Cities Support Program. During the summer of 1993, Arizona architect Jody Gibbs, who had taught construction workshops at MIT for the past seven years, led a group of nine students to Karimabad in the Hunza Valley to study and identify appropriate technologies for the region and analyze the existing housing problems. The four-week project included students from the University of Jordan, Dawood College of Karachi, MIT, and Harvard’s Graduate School of Design, and the results of the workshop were used in the fall studio course. During MIT’s Independent Activities Period (IAP), Mr. Suhaib Raja Khan and Essa Khan from the KPSS, Rahmat Ali of the Aga Khan Housing Board in Gilgit, Stefano Bianca, director of the Aga Khan Trust for Culture’s Historic Cities Support Program, and Didier Lefort, an architect who has been working for the Aga Khan through his secretariat in Aiglemont met with Professors William Porter, Jack Myer, Leslie Norford, Leonard Morse-Fortier, Masood Khan, and Jody Gibbs to lay out the pattern of growth and development that is most advantageous and will prevent new commercial facilities from being poorly placed.

In the fall, students participated in a studio led by Professors Porter, Myer, and Norford, with assistance from Khan and Gibbs, entitled “Northern Areas of Pakistan, a Region in Change: The Match Between Culture and Habitat.” “Insolation and Insulation: How to Make Them Work in Northern Pakistan,” taught by Professors Norford and Morse-Fortier, was offered in conjunction with the first studio. In the spring, Professors Norford and Morse-Fortier offered a building technology laboratory that continued the exploration of technologies appropriate for houses in rural Pakistan.

Assistant Professor Sibel Bozdogan offered architecture and culture courses entitled “The Making of the Discourse on Islamic Architecture,” “Culture and Politics of the ‘Modern House,’” and “Architecture and Modernization: Post-Colonial World.” In March, she organized, along with Rasat Kasaba of the University of Washington, the conference “Rethinking the Project of Modernity in Turkey.” Sponsored by an AKPIA Outreach and Research Grant, it was an interdisciplinary forum, bringing together scholars and cultural critics from the social sciences, the humanities, and architecture, to analyze the experiences of modern Turkey.

History, Theory and Criticism Program (HTC)

New AKPIA student Kishwar Rizvi, from Pakistan, started her SMArchS course work in September. Of the four AKPIA doctoral students in the HTC program, Maha Yahya and Shirine Hamadeh were in residence in Cambridge; Iffet Orbay was in residence in Quebec, writing her dissertation; and Richard Brotherton continued work on his dissertation while based in New York.

During Professor Rabbat’s leave this year, two visiting professors taught Islamic architectural history courses in his absence. Howyda Al-Harithy, an alumna of both the Design for Islamic Societies unit at MIT and the Fine Arts Department at Harvard, taught during the fall semester, and Mina Marefat, an alumna of the History, Theory and Criticism section at MIT, taught in the spring. Professor Al-Harithy taught “Religious Architecture and Islamic Culture” and “Special Studies in Islamic Architecture” while Professor Marefat taught “Building to Power: Persian Architecture from Cyrus to Khomeini” and “Ispahan, Paris, and Washington D.C.”
VISITING SCHOLARS
During 1993–94, the AKPIA hosted four visiting scholars. Hafez Chehab, associate professor and coordinator of the art history program at the State University of New York, College at Brockport, worked on several publications this year including the Mecca bibliography for the Harvard Center for Middle Eastern Studies, and a publication on the Islamic buildings of Palestine, representing research of the Palestine Exploration Fund. Abd al-Razzaq Moaz, an urban architectural historian and researcher from the Institut francois d’etudes arabes de damas, spent six months this fall working on a book about Suwayqat Saruja, a quarter of the old city of Damascus. Madhavi Desai, a faculty member at the Centre for Environmental Planning and Technology and a partner in the architectural firm Archicrafts in Ahmedabad, India, spent three months this spring preparing a manuscript based on her socio-architectural study of the traditional houseform of the Bohra community in Gujarat. Amir Pasic, Bosnian architect and winner of the 1986 Aga Khan Award for the conservation of Mostar’s Old Town, spent his time at MIT completing a book that will present flexible and integrated conservation processes applicable to a variety of cultures and countries. He also prepared a photographic exhibition entitled “Bosnia-Herzegovinia: Before, During and After the War” that he toured to 17 universities and institutions in the U. S. The exhibit was accompanied by a talk, “Mostar 2004,” discussing the destruction of cultural monuments and presenting his plans for the reconstruction of Mostar once the present conflict is resolved.

STUDENT SUPPORT
Tuition and living expenses for one doctoral, twelve SMArchS, one MArch, and one MA student at MIT were funded in whole or in part. Four students from MIT and two from Harvard were awarded summer travel grants for individual research in Morocco, Italy, Jerusalem, Libya, Syria, Iran, and Uzbekistan. One MIT student was awarded a travel grant for thesis research in Turkey. One Harvard and two MIT students were chosen to participate in internships: one with an architectural firm in Orangi, Pakistan, and the other two with the 1993–94 AKP Visiting Scholar Amir Pasic in a workshop located in Istanbul on the reconstruction of Mostar.

LIBRARY RESOURCES AND PUBLICATIONS
Specialized acquisitions and services at the Rotch Architecture Library continued to be provided through endowed funds. The AKPIA archivist at the Rotch Visual Collections (RVC) for the past ten years, Kim Lyon, left her position to complete her graduate studies. Librarian Katy Poole has been assisting students and faculty with the AKPIA collections at the RVC while the search for a new archivist proceeds. The AKPIA’s videodisc system, Images of Islamic Architecture, continued to be a valuable resource to students, faculty, and staff. Omar Khalidi, reference librarian for the AKPIA at the Rotch Library, continues to assist students and faculty with the AKPIA book collection.

The AKP librarians at Harvard and MIT worked together to formulate a resource packet, complete with guidelines, for setting up an academic collection on Islamic architecture. Originally formulated to assist building the collections at the parallel centers in Jordan and Karachi, the packet should be of use to all architectural libraries in the Muslim world.

The Program publishes, through other organizations, scholarly works on the history of Islamic art and architecture. Its major publication is an annual volume of essays on art and architectural history entitled Muqarnas, published by E.J. Brill in Leiden. This year, Publications Coordinator Margaret Severcen completed editing the manuscript of Muqarnas 11. The publication Ars Orientalis XXIII: A Special Issue on Pre-Modern Islamic Palaces, a collection of articles based on papers presented at a two-day symposium held in May 1992 and sponsored by the AKPIA, was published by the University of Michigan and released this year.

BARBRO M. EK
The Center for Real Estate (CRE), founded in 1984, carries out research and teaching programs in the field of real estate development, investment, and management. It also provides a forum for the exchange of information and the discussion of issues by real estate professionals from around the world. The center’s principal activities include an 11-month mid-career professional degree program leading to a Master of Science in Real Estate Development and a research agenda of issues relating to the planning, development, and management of real estate, including its financial performance.

In addition to its usual education, research and membership activities, this year the center published “The US Real Estate Market: An Economic Outlook for the 1990s,” the first of what is intended to be an annual report on real estate markets by sector. The report is based on econometric modeling, and is more likely to project accurately beyond the current year than other types of forecasting widely used in the real estate industry. The author of the study is William C. Wheaton, Professor in the Departments of Economics and Urban Studies and Planning, and Director of the center. The report was distributed to members of the center and sold to the industry. Its production was subsidized by five member firms.

Thomas A. Steele left his position as Chairman of the center at the end of December, but he continues on at MIT as head of the China Collaborative, an initiative by the School of Architecture and Planning to form a partnership among the School, Tsinghua University in Beijing, and the PRC Ministry of Construction. The goal of the collaborative is to provide research and market information about the real estate market in Shanghai and to teach Chinese academics and officials about planning and development issues in a market economy.

EDUCATION

Thirty members of the ninth class of CRE graduates received their S.M. degrees in Real Estate Development in October, 1993. Two more members of the class received their degrees in February, 1994. Four joint degree students completed the requirements at CRE and will receive their degrees upon completion of their other academic programs. The incoming class, the 31 members of the Class of 1995, which includes five joint degree candidates, were selected in March. The international component of this class is unusual in that four class members are currently working in Thailand. The two from South America will be the first CRE students from that part of the world.

In view of the increasing complexity of real estate finance, course requirements for the degree were revised to add a general finance course. Students are now required to enroll in either 15.412 Financial Management II or 15.415 Finance Theory in addition to Real Estate Finance and Investment. The plan is to expand the real estate finance course to two terms in the coming year to increase the amount of time allotted to the study of real estate capital markets. This will bring the number of core courses required for the degree back to eight, in addition to the thesis.

Timothy J. Riddiough, Assistant Professor of Real Estate at the University of Cincinnati, accepted an appointment as Assistant Professor in the Department of Urban Studies and Planning. He will revise and teach the core course in real estate finance next year. His office will be located at the center.

The Pension Real Estate Association (PREA) has selected MIT as one of four schools to receive $5,000 scholarships for the next two academic years. The scholarships will be awarded to students interested in pursuing a career in institutional real estate investment and management.

RESEARCH

Sandra Lambert, Lecturer in the Department of Urban Studies and Planning, has been engaged this year in phase two of a “CRE 2000” project on the management of corporate real estate. It is sponsored by the Industrial Development Research Council and Foundation. Ms. Lambert is the Principal Investigator for the organizational strategy segment of the project, which continues to investigate the question of how the real estate unit adds value to the corporation. Michael Joroff, Director of Research Development for the School of Architecture and Planning, is the overall project director.

The center published two working papers this year. John Crowley, Research Associate in the Department of Architecture and Jordan Dentz, a 1991 master’s degree graduate in Building Technology, studied technology transfer in the building materials industry using the case of a new roof component system developed by the Innovative Housing Construction Technologies program. They found that a number of factors limited quick transfer of the new roof system, chief among them being high cost of the prototype system, incompatibility with the current business strategies of possible manufacturers, and insufficient potential returns to attract investors. Zhizhong Yang, Ph.D. candidate in the Department of
Urban Studies and Planning, looked at emerging land markets in Shanghai, China, in a paper based on his master’s thesis. He argued that distinctive features of the land market, including a unique property rights structure and a strong government role, will continue to affect the prospects for successful real estate development into the foreseeable future.

PROFESSIONAL EDUCATION
The center’s professional education program included the sixth session of the Minority Developer’s Executive Program (MDEP). As in past years, participants came from major cities across the country as well as from New England, to study for ten days on campus. The program emphasizes financial and business planning skills and is taught by MIT faculty pro bono and by practitioners from the Minority Developers’ Association of Boston and from the Bank of Boston, which remains the principal financial partner of the project. The Minority Property Management Executive Program, developed in partnership with the Massachusetts Housing Finance Association, held its second session in July. Like the MDEP, it emphasizes business and financial planning, but adds to that a focus on managing staff and internal systems and controls.

The ninth summer of short professional development courses brought more than 200 real estate professionals to MIT, mainly from the United States, though a few came from abroad. Five short (2- to 2.5-day) courses were offered, including two new ones (Asset Management and Advanced Real Estate Finance) which proved popular.

Faculty members again traveled abroad, this time to Taipei, to present a two-day seminar on Successful Real Estate Investing to the real estate community there.

MEMBERSHIP
Income from membership rose for the third year in a row, and the center closed the year with 87 supporting members (including 23 offshore members), a net gain of two over the previous year. The center added six new member firms in 1994. Members continue to support the center in non-financial ways as well, providing case study sites, lecturing in classes, and speaking in the Rose Lunchbox Series. Member support of student thesis research (suggesting research questions, providing data, and paying expenses) has been encouraged by the center and has increased significantly over the past two years.

Semiannual members meetings were held in December and June. The topic of the winter meeting was Economic Growth and US Real Estate Markets. Paul Krugman, Professor of Economics discussed the likely effects of trade agreements on the world economy at the evening session. In the morning, Professor Wheaton presented market outlooks for the multi-family residential, office, and retail sectors, based on research done for the center’s real estate report. Commenters from the real estate industry also spoke, provoking a lively discussion among the eighty members present. The June meeting, Residential Real Estate: New Ways to Finance It, Design It, Own It, covered a number of new ideas in the housing area. The evening session featured Olivier Blanchard, Professor of Economics, describing his research on the reduced returns to equity holdings. In the morning, two academics and two practitioners took the floor. In the financial area they described new ways for institutions to invest in single-family housing equities, and the possibility of developing a hedging mechanism to protect investments in single-family mortgages. In the product area, they described how to exploit the niche market for senior housing, and discussed the impacts of neo-traditionalist planners on life in the suburbs.

The center also held two special meetings. One was for members and alumni in New York City to introduce the research of Rose Professor of Urban Economics, Frank Levy to the real estate community there. Other speakers in the morning program included Professor Wheaton and William Mitchell, Dean of the School of Architecture and Planning. A second was in Cambridge for members of the Epoch Foundation who visited MIT in April under the auspices of the industrial Liaison Program. Ten Epoch Foundation members are also members of the Center for Real Estate.

ADMINISTRATION
Blake Eagle was appointed Chairman of the center in January. He is taking a three-year leave from the Frank Russell Company of Tacoma, WA, where he was President of Real Estate Consulting. Mr. Eagle, who is well known in the real estate investment community, played a lead role in developing the Russell-NCREIF Property Index, the first large-scale published data on the investment performance of the different property sectors. Mr. Eagle is the center’s primary liaison with the membership and the real estate industry. Patricia Brady remains the Associate Director.

WILLIAM C. WHEATON
INTRODUCTION
1993-94 is a distinct cusp in the history of personal computing. Public awareness and the sheer presence of multimedia, personal computing, and the information super-highway has skyrocketed. The cover of almost every popular magazine reflects this change and actual usage supports it: 35 percent of American homes have a PC, 65 percent of all PCs will be sold to the home market, and the Internet is growing exponentially (Mosaic grew at 11 percent per week). The fundamental purposes of the Media Lab first moved from the fringes of computer science to the mainstream; now they have become a centerpiece to life itself.

The impact on the Lab has been a heightened interest from every direction. US content providers from Hollywood to Wall Street want to repurpose their archives and protect their bits. Early publishing models are subject to change, one which may benefit authors and readers but not the distribution business. European public PTTs are trying to catch up and learn from early deregulation in the US and the growing theme of "bits are bits." Japan Inc., by contrast, has retreated a little under the force of its recession and political turmoil.

A concept is clearly emerging: The future of "being digital" concerns both channel and content, both means and messages, both technology and information, both interactivity and narrative. The Media Lab finds itself well positioned for this future, given the strong applications imperative which stems from faculty and students committed to music, video, animation, story telling, graphics, and the human acquisition of knowledge. Combined with strong technical programs in computer vision, media physics, artificial intelligence, image processing, human factors and holography, the Lab enjoys a recognized uniqueness.

The red flag for us this year is different from concerns of the past. It concerns our long-term future and our ability to sustain sufficiently crazy ideas, so that some part of the Lab will always be at the lunatic fringe. Otherwise, as we become more and more established, it is possible that we may become old news and slip into a mold of complacency which would put us into a downhill slope toward boring research. The challenge is a continuing one: To keep this from happening.

SPONSORS
Research Sponsors
The Media Lab’s research volume continued to grow albeit modestly in FY 1994 — from $10.5 million in FY 1993 to $11.3 million in FY 1994 for a growth rate of 7.6 percent. That research volume continued to be sponsored primarily by industry (71 percent) with the US Federal government (ARPA, JNIDS, ONR, Dept. of Army, and NSF) supporting 29 percent of total volume. On a regional basis, Europe continued strong with regional industrial support shares of 24 percent Europe, 16 percent Far East, and 60 percent North America.

Directed Sponsors
New Directed Research Sponsors during FY 1994 included the following:

- NSF provided a Young Investigator’s Award to Professor Mitchel Resnick.
- The Army Research Laboratory in Adelphi, MD contracted with Professor Alex P. Pentland for a three year program in “Face Recognition Technology.”
- During the year, Bertelsmann AG and Sun Microsystems joined the Laboratory’s Television of Tomorrow (TVOT) Consortium which included the following members at the end of the year:
  
  Eastman Kodak  
  Sun Microsystems  
  Hughes Aircraft Company  
  Bertelsmann AG  
  Deutsche Bundepost  
  Phillips
Next year, Intel and Viacom International plan to transfer their membership in the Movies Consortium to the TVOT Consortium as the research agendas merge.

Also, during the year, four new members joined the News in the Future (NiF) Consortium including The Chronicle Publishing Company, Editoriale L'Espresso S.p.a., Lotus Development Corporation, and Thomson Newspapers Corporation for the following NiF membership at the close of the year:

Aamulehti Group, Inc.
ABC Radio Networks and
Capital Cities/ABC Publishing Group
Advance Publications, Inc., and Newhouse Broadcasting Corporation
BellSouth Enterprises, Inc.
The Chronicle Publishing Company
Editoriale L'Espresso S.p.a.
Gannett Co., Inc.
Globe Newspaper Company
Grupo Consolidado
Hearst Corporation
Knight-Ridder, Inc.
Lotus Development Corporation
McCann-Erickson Worldwide
Pulitzer Publishing Company
Reed Elsevier plc
Televisia s.a. de c.v.
Thomson Newspapers Corporation
The Times Mirror Company
Tribune Company
Ziff-Davis Publishing

Special Funds and Equipment Gift Sponsors
AMP Incorporated continued both its cash and hardware gift support for the Laboratory's four-year $3.5 million building-wide fiber optic network. Wellfleet Communications continued hardware support. The network installation is ahead of schedule and was about 60 percent complete by the end of the year. AMP is providing cable, connectors, patch panels, and concentrator electronics, allowing the Lab to run Ethernet, FDDI, ATM, and future network technologies over the same plant and enabling - but not forcing - migration to higher speeds as necessary. Wellfleet routers constitute the head of the network, enabling diverse local-area technologies to communicate, as well as providing a strong capability for wide-area networking. Raylan, a company partially owned by AMP, is supplying signal concentration electronics for ethernet applications.

Hewlett Packard company continued financial support for the research programs of Professors Rosalind W. Picard and Neil Gershenfeld for the second year. It also provided a second year of major hardware support for Professor Gershenfeld's Physics and Media Laboratory and for Professor Picard's work in Vision Texture. That equipment included upgrades for 2 workstations; 11 more workstations and PC's; and general laboratory and test equipment.

The new Interval Research Corporation special fund supported Professor Aaron F. Bobick and his dynamic scene annotation research activities. Unlike most previous work in computer vision which considers the content of static images, this work seeks to generate descriptions of what is happening in a dynamic scene.
The first Interval Student Fellows were named in the fall of 1993 — Amy Bruckman, Alex Rigopulos, Barry Arons, and Anil Chakravarthy. Fang Liu was appointed as Interval Student Fellow in the spring, following Dr. Arons’ graduation. During the summer of 1994, Anil Chakravarthy, Fang Liu, and Marc Davis were in residence at Interval as Interval Graduate Fellows, three MAS graduate students were in residence as summer employees, and two former MAS students had joined the regular Interval staff.

As the year drew to a close, AT&T executed a new five-year agreement to establish the AT&T Digital Media Research Fund which will provide a total of $1.25 million over five years for the support of three to five specifically selected Media Arts and Sciences Program students as AT&T graduate fellows each year. The Fund will encompass graduate students from all areas of the Laboratory and provide them with a full research assistantship or graduate fellowship. The Director of the Media Laboratory and an AT&T Program Manager will each year agree on the specific students to be selected for these graduate awards.

NEC continues to provide special fund support for Professor Picard, who holds the NEC Career Development Chair, specifically targeted to her work in Texture and Image Models, Semantic Signal Processing, and Pattern Perception. NEC, also very generously, provided a deep discount and an outright gift of a significant number of 16 MB/Simms for use in the Laboratory’s CHEOPS project.

Festo Didactic KG of Germany provided new special fund support for both Professors Gershenfeld and Resnick’s research in Smart Air — For Complex Pneumatic Systems: MPS for the Masses — extending the functionality of the “programmable brick” technology; and Facile Fabrication — upgrading, expanding, and enhancing the Laboratory’s hardware construction facilities.

Apple Computer, Interlego A/S, Mitsubishi, and Toshiba all continued to provide special funds in support of specific faculty and projects.

Digital Equipment Corporation provided major equipment gift support including upgrading 28 DEC workstations to Alpha, adding 9 more Alpha workstations, and providing equipment for the fiber optic network.

Silicon Graphics, Inc. provided three fully loaded Reality Engines and two Indigos under special use terms equivalent to SGI’s internal cost. SGI is therefore considered an equipment gift sponsor.

Media Technology Fund Sponsors
New Media Technology Fund Sponsors during the year included:

- Casio Computer Co. Ltd.
- The Korea Institute of Science & Technology (KIST)
- Nippon Columbia Co., Ltd.
- Saatchi & Saatchi North America, Inc.
- Tele Danmark A/S

Professorships
Two old friends of the Media Laboratory agreed to fund new Professorships during FY 1994.

AT&T Career Development Professorship of Media Arts and Sciences
In addition to the special AT&T Digital Media Research Fund described above, AT&T is also providing funding, over a period of five years, for a Career Development Professorship. The future of the Media Laboratory and AT&T seem collinear, not only because we share an interest in what is called multimedia, but because of our innovative computer services.

The GoldStar Career Development Professorship of Media Arts and Sciences
GoldStar renewed its long-term support for the Laboratory with this Professorship. A GoldStar research affiliate will be resident at the Lab. GoldStar is a major Korean conglomerate and one of the world’s leading manufacturers of consumer electronic products, computer and office automation equipment, and home and industrial appliances.
PERSONNEL
Ms. Patricia Peterson joined the Communications and Sponsor Relations group of the Lab in December as editor of the sponsor newsletter FRAMES and of other Media Lab publications. Mr. Ronald S. Newman, Research Specialist, joined the research team headed by Professor Kenneth B. Haase working on the FRAMER representation systems for the News in the Future research project. Mr. Gadi Geiger was appointed Visiting Scientist to the Media Laboratory for two years beginning on January 1, 1994. Mr. Geiger's research is on the physiological theory of task-dependent states of perception. Mr. Geiger is working with Professor Emeritus Jerome Lettvin in Building 20. Mr. Carlton Sparrell joined the Media Lab on June 1, 1993, as a temporary Research Specialist in the Spatial Imaging Group after completing his Masters degree in Media Arts and Sciences. Mr. Ryan Evans joined the staff of Communications and Sponsor Relations as a temporary Research Specialist (6 months). Dr. Joe Paradiso has accepted a one-year Research Scientist appointment with the Music and Physics Group of the Media Lab to work on the News in the Future research project beginning July 1, 1994. Mr. Richard Broberg was joined the Technical Services group as a Systems Programmer on June 1, 1994. Mr. Kirk Noda was appointed Technical Assistant for one year beginning June 1, to work on the installation of the Fiber Optic network.

Mr. Walter R. Bender was appointed Associate Director for Information Technology of the Media Lab on January 1, 1994. Mr. Bender is a founding member of the Media Lab and is the Director of the News in the Future research consortium.

Ms. Laureen R. Chapman, formerly Administrative Assistant in the Perceptual Computing Group, was promoted to the Sponsored Research administrative staff and is now working in the Finance and Administration Group of Media Lab Headquarters.

New Research Affiliates of the Lab include Dr. Sung-Jae Kwon of Goldstar, Co., Ltd. of Korea, Dr. David Allport of Hewlitt-Packard Laboratories in Bristol, England, and Mr. Akira Kotani of Mitsubishi Electric of Japan.

Ms. Penny Blaisdell, Director of Communications and Sponsor Relations, left the Media Lab in October 1993 for a marketing position in the private sector. Mr. Christopher Gant was named Acting Director of Communications and Sponsor Relations of the Media Laboratory, effective October 1, 1994.

Ms. Alice T. Markunas, Purchasing and Travel Coordinator, retired from the Media Lab on June 30, 1994, after 12 years of service at MIT. Ms. Markunas has worked in the Finance and Administration Group of the Media Lab since its founding in 1985, and prior to that worked with the Architecture Machine Group, the precursor to the Media Lab. Mr. Jan Matlis terminated from the Lab after 9 months as a Research Specialist for the Perceptual Computing Group. Dr. Idit Harel, Research Associate, left the Media Laboratory in December of 1993 to pursue research in the private sector. Mr. Stuart R. Cody, video technical staff, left the Lab on July 1, 1994, to work full time as proprietor of his own video production firm.
MEDIA LABORATORY SPONSORS
The following list indicates Media Laboratory Sponsors (as of June 1, 1994) according to the categories of sponsorship defined in Intellectual Property Rights of Media Laboratory Sponsors:

RESEARCH CONTRACTS
Alenia
Apple Computer
ARPA
AT&T
Bell Communications Research
BT
Department of the Army
Digital Equipment Corporation
Hewlett-Packard
Honda R&D Company, Ltd.
Interlego A/S
International Business Machines
JNIDS
National Science Foundation
NEC
Nynex
Office of Naval Research
SEGA of America, Inc.
Sun Microsystems
Thomson-CSF
Toshiba
Yamaha

RESEARCH CONSORTIA
Movies of the Future
Bell Communications Research
Intel
Viacom International

News in the Future
Aamulehti Group, Inc.
ABC Radio Networks and
Capital Cities/ABC Publishing Group
Advance Publications, Inc., and
Newhouse Broadcasting Corporation
BellSouth Enterprises, Inc.
The Chronicle Publishing Company
Editoriale L’Espresso S.p.a.
Gannett Co., Inc.
Globe Newspaper Company
Grupo Consolidado
Hearst Corporation
Knight-Ridder, Inc.
Lotus Development Corporation
McCann-Erickson Worldwide
Pulitzer Publishing Company
Reed Elsevier plc
Televisa s.a. de c.v.
Thomson Newspapers Corporation
The Times Mirror Company
Tribune Company
Ziff-Davis Publishing

Television of Tomorrow
Bertelsmann AG
BNR/Northern Telecom
Deutsche Bundespost Telekom
Eastman Kodak
Hughes Aircraft
Philips
Sharp
Sony
Sun Microsystems
Televisa s.a. de c.v.
Toppan Printing Co., Ltd.

MEDIA TECHNOLOGY GROUP
BT
Casio Computer Co., Ltd.
Creative Technology Ltd.
EDS
Fujitsu Laboratories, Ltd.
Goldman Sachs Group, L.P.
Hughes Aircraft
IRI Group
Kodansha Ltd., Publishers
Korea Institute of Science and Technology (KIST)
Microsoft
Motor-Columbus AG
News Corporation, Ltd.
Nippon Columbia Co., Ltd.
Pioneer Electronic
Reuters
Saatchi & Saatchi
North America, Inc.
Tele Danmark A/S
Thinking Machines

SPECIAL FUNDS
AMP
Apple Computer
Bertelsmann AG
Festo KG
Hewlett-Packard
Interlego A/S
Interval Research Corporation
Mitsubishi Electric
NEC
Toshiba

MAJOR EQUIPMENT GIFTS
AMP
Apple Computer
Digital Equipment Corporation
Hewlett-Packard
International Business Machines
Silicon Graphics
Sony Industrial Products
Sun Microsystems
WELLFLEET Communications

ENDOWMENT AND NAMING GRANTS
Rudge and Nancy Allen
Armand and Celeste Bartos
Asahi Broadcasting Corporation
AT&T
Fukutake Publishing
GoldStar
Misawa Homes
Interlego A/S
Phillipe Villers
NEC
Schlumberger
Sony
Toshiba
LIST OF MEDIA LABORATORY PROJECTS

I. Learning & Common Sense
1. Children and Machines
2. Memory-Based Representation
3. Understanding News
4. Iconic Stream-Based Video Logging
5. Storyteller Systems
6. FRAMER: Knowledge Description and Sharing
7. Graphics by Example
8. Graphics for Software Visualization
9. The Berlin Wall of Programming
10. Intelligent Technical Documentation
11. Graphical Annotation
12. Instructible Agents
13. Agent-Application Communication
14. Autonomous Agents
15. Interface Agents
16. Editors, Agents, and Butlers
17. Society of Mind
18. Animal Construction Kits
19. Structure out of Sound
20. Constructionism
21. Robot Design Competitions
22. Project Headlight
23. Learning in Multicultural Settings
24. Science and Whole Learning Teachers’ Collaborative
25. Electronic Communication
26. Children as Designers
27. Games
28. Study of Mathematical Thinking
29. Thinking and Learning about Systems
30. Ubiquitous Computing for Kids
31. New Visions of Programming in Education
32. Learning in Virtual Communities

II. Perceptual Computing
33. Mid-Level Vision
34. X-Y-T Image Analysis
35. Analysis of Egomotion Using Wide Angle Vision
36. Modeling and Tracking People
37. Dynamic Scene Annotation
38. Multimodal Natural Dialog
39. Advanced Interactive Mapping Displays
40. Information Appliances
41. Structure out of Sound
42. Looking at People
43. Model-Based Image Coding
44. Video Databases: Indexing by Content
45. Image Query by Texture Content
46. Nonlinear Space-Time Texture Models
47. Semantic Image Modeling
48. Computers and Telephony
49. Desktop Audio
50. Voice Interfaces to Hand-Held Computers
51. Voice Hypermedia
52. Telephone-Based Voice Services

II. Perceptual Computing (cont.)
53. Synthetic Performers
54. Synthetic Listeners
55. Synthetic Spaces
56. Cognitive Audio Processing
57. Structured Audio Transmission

III. Information & Entertainment
58. Salient Stills
59. Color Semantics
60. Knowing the Individual
61. Interactive Computation of Holographic Images
62. Scaled-Up Holographic Video
63. Holographic Laser Printer
64. Immersive Projected-Image Holographic Displays
65. Medical Image Holography
66. Edge-Lit Holograms
67. Open Architecture Television
68. Cheops: Data-Flow Television Receiver
69. Motion Modeling for Video Coding
70. Production, Distribution, and Viewing of Structured Video Narratives
71. Multimedia Testbed
72. Computationally Expressive Tools
73. Large-Scale, High-Resolution Display Prototypes
74. Input/Output Considerations
75. Advanced Interactive Mapping Displays
76. Experiments in Elastic Media
77. Video Editing: Computational Partnerships
78. Stories with a Sense of Themselves
80. Storyteller Systems
81. Production, Distribution, and Viewing of Structured Video Narratives
82. Real-Time Modeling
83. Interface Sensors and Transducers
84. Information, Computation, and Physics
85. Incremental Coding
86. Movies via Modems
87. Objective Coding
88. Dimensionalization
89. Casual Collaboration
90. Structure out of Sound
91. Hyperinstruments
The School's major accomplishment in the past year was the publication of its Long Range Plan for the years 1994-98. This was the third Long Range Plan for the School in the past dozen years. The Plan emphasizes a gradual shift in engineering from an education and research program that emphasizes engineering science to one that is more oriented toward engineering practice. The Five Year First Professional Degree program, first introduced in the Electrical Engineering and Computer Science Department last year, has some of this practice oriented character. We anticipate that similar Master of Engineering (M.Eng.) programs will be introduced in the Aeronautics and Astronautics, Civil and Environmental, and Ocean Engineering Departments in the coming years.

A second major recommendation of the Long Range Plan is the development of a new graduate program, parallel to the Leaders for Manufacturing Program, that emphasizes the design of large scale systems. The Sloan School of Management has agreed to cooperate in the development of this program, and has chosen to make it the top priority in its new Five Year Plan under the School's newly appointed Dean, Professor Glen Urban. The proposed program will likely rely, in part, on distance education from MIT to the companies in which the students work.

A third recommendation suggests that the School's research programs be more closely aligned with industrial needs and interests. While the details of such future interactions need to be worked out, we believe that greater involvement with industry will lead to a better, more balanced education for our students, particularly at the graduate level. We have seen this benefit for decades in our cooperative or internship programs. The issue is whether such experiences can also benefit the School in other ways, in particular motivating teams of students and faculty.

**Education and the School of Engineering**

The School of Engineering Education Committee (SEEC) acts as the major platform for discussion and interchange on major issues associated with undergraduate and graduate engineering education. During this past year, SEEC divided its time between four major topic areas. First, the School's Long Range Plan emphasized the importance of the hands-on experience in undergraduate engineering education. SEEC reviewed the opportunities for hands-on experiences in the engineering departments and the Edgerton Center in preparation for defining a School strategy for enriching the hands-on experience for our students. Second, in cooperation with the School of Science and the Undergraduate Education and Student Affairs Office, SEEC continues to pursue opportunities to improve the freshman core to better suit the needs of engineering undergraduates.

SEEC has reviewed the experience of the Department of Electrical Engineering and Computer Science in implementing its five year first professional degree program, been informed of the parallel effort in Aeronautical and Astronautical Engineering, and discussed future plans for five-year programs and second professional degrees in other engineering departments. In addition, SEEC worked with the Biomedical Engineering Program in its efforts to construct a minor program and begin the approval process for this Minor in Biomedical Engineering. This is the first non-departmentally centered minor to be proposed.

Outside of the above SEEC activities, the Dean's Office has played an active role in supporting hypertext/hypermedia efforts in the Departments of Mechanical Engineering and Electrical Engineering and Computer Science.

**AWARDS**

**The Bose Award for Excellence in Teaching** was presented this year to Professor Michael F. Rubner of the Department of Materials Science and Engineering. The Bose Award is funded with a gift from the Bose Foundation and is awarded each year to one faculty member in recognition of outstanding contributions to undergraduate education.

**The Ruth and Joel Spira Awards for Teaching Excellence** were presented this year to Professor Elias Gyftopoulos of the Department of Nuclear Engineering, Professor Anthony Patera of the Department of Mechanical Engineering, and Professor Martin A. Schmidt of the Electrical Engineering and Computer Science Department. The Spira awards were established with a gift from Mr. and Mrs. Joel Spira to honor outstanding teachers in the three departments listed above.

**Henry Ford II Scholar Award** - This award is presented to the senior in the School of Engineering who has attained the highest academic record at the end of the third year and who has exceptional potential for leadership in the profession of engineering and in society.

The recipient this year was Ms. Tracy E. Adams of the Department of Electrical Engineering and Computer Science.
Barry M. Goldwater Scholarship - This scholarship is awarded on the basis of merit to students who are sophomores or juniors and who have excellent academic records and have demonstrated an interest in and potential for careers in mathematics, the natural sciences and those engineering disciplines that contribute significantly to the technological advances of the United States.

This year we had two scholarship winners from the School of Engineering: Albert Lau a junior in the Department of Chemical Engineering and Phillip Phuc Van Le a junior in the Department of Electrical Engineering and Computer Science.

Reinhold Rudenberg Memorial Fund - This prize is awarded to students based on their senior theses in the area of energy conversion.

Two awards were made this year, to Rajesh Suryadevara of the Laboratory for Electromagnetic and Electronic Systems for his thesis entitled: "A Digitally Controlled Thermoelectric Temperature Regulator" and to Goro Tamai of the Energy Laboratory for his thesis entitled: "Data Analysis of Piston Motion and Engine Block Response Characteristics in Piston Slap."

ENROLLMENT

Overall, enrollment in the School of Engineering remained stable in 1993-94. Undergraduate enrollment increased by 1% while graduate enrollment increased by about 2%. Undergraduate enrollment in Aeronautics and Astronautics continued to decline although the rate of decline has moderated. Chemical Engineering's undergraduate population continued to grow. Undergraduate enrollment in Materials Science and Engineering which had increased during the previous two years, declined by 12% in AY93-94. Undergraduate enrollment in Nuclear Engineering grew by 10 (up 43%) for the second year in a row. The largest shifts in graduate enrollment occurred in Ocean Engineering (up 15%) and in Civil and Environmental Engineering where graduate enrollment grew by 19 (7%) reversing the 1992-93 downturn in that department's graduate population.

<table>
<thead>
<tr>
<th>Undergraduate Enrollment</th>
<th>Graduate Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct. '93</td>
<td>Change '92-'93</td>
</tr>
<tr>
<td>A&amp;A</td>
<td>137</td>
</tr>
<tr>
<td>CHEM</td>
<td>303</td>
</tr>
<tr>
<td>C&amp;EE</td>
<td>127</td>
</tr>
<tr>
<td>EECS</td>
<td>970</td>
</tr>
<tr>
<td>MS&amp;E</td>
<td>127</td>
</tr>
<tr>
<td>MECH</td>
<td>460</td>
</tr>
<tr>
<td>NUCLEAR</td>
<td>33</td>
</tr>
<tr>
<td>OCEAN</td>
<td>9</td>
</tr>
<tr>
<td>CAES</td>
<td>52</td>
</tr>
</tbody>
</table>

Affirmative Action

During the past year, seven of the fifteen faculty offers in the School of Engineering were made to women or minorities. Women are now represented on the faculties of all eight academic departments and the number of women faculty stands at twenty-five, an all time high.

Our efforts to recruit minority faculty continue. During the decade preceding initiation of the President and Provost's program to recruit underrepresented minority faculty members, faculty positions were offered to only four underrepresented minority candidates. In contrast, over the last three years, seven faculty positions have been offered to underrepresented minorities and the number of Black, Puerto Rican and Mexican American faculty members in the School is expected to grow from five to nine in the next year.
An initiative which we hope will yield long term results was the publication of a booklet entitled *Graduate Engineering and Underrepresented Minorities at MIT*. The booklet which was modeled after a 1992-93 publication for women, *Graduate Engineering and Women at MIT*, features all of the underrepresented minority faculty in the School as well as thirteen distinguished underrepresented minority alumni. Copies of the booklet have been distributed to the departments and to the Office of the Dean of the Graduate School where they will be used to recruit minority graduate students.

The School was also successful in its bid for a General Electric Foundation Faculty for the Future Award. The goal of the Foundation's program is to increase the number of women and underrepresented minorities on engineering faculties throughout the United States. Grant funds will be used to encourage women and minorities at each stage of the pipeline and provides support for undergraduate research, graduate fellowships and forgivable loans for Ph.D. candidates interested in teaching careers, and start-up funds for new women and underrepresented minority faculty members.

**Faculty Size**

During 1993-94, fourteen individuals joined the School's faculty while seventeen faculty members resigned or retired. The School's authorized faculty headcount, including TBA's, dropped from 368 to 366.

**Engineering Council**

Over the past year, Engineering Council acted on nine cases for promotion to full professor and seven cases for promotion to and/or appointment as untenured associate professor. Council also acted on eight internal tenure cases and two cases to appoint new faculty to tenured positions.

Professor John Guttag was named Associate Head of Electrical Engineering and Computer Science, succeeding Professor Fernando Corbato who returned to regular faculty duties as Ford Professor of Computer Science and Engineering. Professor Corbato served on the Council with distinction for over a dozen years. His insight, his thoughtful approach to problems and issues, and his humor will be missed.

Professor Lionel Kimerling was named Director of the Materials Processing Center, succeeding Professor Thomas Eagar who had previously been appointed Co-Director of the Leaders for Manufacturing Program. Professor Timothy Gutowski was named Director of the Laboratory for Manufacturing and Productivity, succeeding Professor David Hardt who returned to regular faculty duties. Professor Richard Lester joined Engineering Council this year when the Industrial Performance Center of which he is the Director became part of the School of Engineering.

**ENGINEERING INTERNSHIP PROGRAM (EIP)**

In 1993-94, twenty-four sophomores were placed as interns with member companies. The total number of interns in the program is currently sixty-three. This is the continuation of a depressed state of the economy in a number of our member companies. The corresponding totals in 1992-93 were 32 and 70.

From conversations with company representatives, it appears that a rebound in recruitment can be expected but the prior level of activity may not be reached in the near term.

**CONCOURSE PROGRAM**

**Enrollment**

Forty-eight students enrolled in Concourse for all term which represented a 21% decrease from fall of 1993. Spring term's enrollment was 38, a 16% decrease from the previous year.

**Highlights**

Concourse received a $10,000 award from the Class of 1951 Excellence in Education Fund to continue and expand one of the educational initiatives begun last year. Originally entitled "Problem Solving in Science and Technology," the class met again during IAP 1994, with great success. It was reported on by *Science* magazine and *The Boston Globe*, and we are now contracted to write a book (entitled "From Russia With Love"), the manuscript for which should be finished this fall. Our IAP student lecture note project (lecture notes written by students for students) yielded an appendix on crystal structure and a chapter on X-ray diffraction. In response to this year's decreased enrollment and in order to best meet the needs of our students and still contain costs, major changes in our curriculum are planned for next year. During the fall of
1994, we will offer both 18.01 Calculus I and 18.02 Calculus II along with 9.00 Introduction to Psychology. During the spring term, 7.012 Introduction to Biology will replace our spring term humanities course.

MINORITY INTRODUCTION TO ENGINEERING AND SCIENCE (MITES)

At the end of 1993-94, fifty-one high schoolers will be resident on campus for MITES '94. There are currently eighty-five ex-MITES students pursuing undergraduate and graduate studies here. At a recent awards banquet, twenty of fifty-two students with GPA's of 4.2 or better were identified as ex-MITES participants.

The plans to expand MITES session attendance from 50 to 100 continue to hold due to the economic woes facing a number of the program sponsors.

JOEL MOSES
The Department implemented its new S.B. program curriculum with the class of 1996 - this year's sophomores - whose class size was again in the mid 30's. Graduate enrollment remained around 200 with about sixty doctoral students, a couple of Engineer candidates, and the remainder enrolled for the S.M. degree. Detailed plans were developed for the fall 1995 introduction of the Master of Engineering degree. The Department actively participated in the planning for a new Master of Engineering and Management professional degree to be offered jointly by the School of Engineering and Sloan School of Management. Two of our faculty retired, five new faculty were appointed, and two faculty were promoted to Associate Professor with Tenure. Department research activities remained at the same high level as in past years. Once again, the Department was ranked as the top aerospace engineering school in the country by U.S. News and World Report for its outstanding education and research programs.

A highlight of the year was the 25th Lester D. Gardner Lecture on "Engineering Aspects of a Lunar Landing" delivered by Dr. Robert C. Seaman Jr. and Neil Armstrong on May 3, 1994 to an overflow audience in Room 26-100. At a gala dinner following the lecture, the Department announced the establishment of the Apollo Program Professor of Astronautics - a senior faculty chair to be filled for the 1995-96 Academic Year.

UNDERGRADUATE PROGRAM

Undergraduate Enrollment over the Last Ten Years

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Soph.</td>
<td>99</td>
<td>106</td>
<td>120</td>
<td>96</td>
<td>103</td>
<td>75</td>
<td>76</td>
<td>61</td>
<td>33</td>
<td>36</td>
</tr>
<tr>
<td>Juniors</td>
<td>90</td>
<td>92</td>
<td>103</td>
<td>118</td>
<td>94</td>
<td>87</td>
<td>61</td>
<td>62</td>
<td>60</td>
<td>31</td>
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<tr>
<td>Seniors</td>
<td>93</td>
<td>106</td>
<td>98</td>
<td>105</td>
<td>130</td>
<td>104</td>
<td>104</td>
<td>73</td>
<td>66</td>
<td>66</td>
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<tr>
<td>Totals</td>
<td>282</td>
<td>304</td>
<td>321</td>
<td>319</td>
<td>327</td>
<td>266</td>
<td>241</td>
<td>196</td>
<td>159</td>
<td>133</td>
</tr>
<tr>
<td>% of women</td>
<td>18%</td>
<td>18%</td>
<td>16%</td>
<td>19%</td>
<td>21%</td>
<td>25%</td>
<td>23%</td>
<td>27%</td>
<td>28%</td>
<td>32%</td>
</tr>
<tr>
<td>% of Underrep. minority students</td>
<td>10%</td>
<td>11%</td>
<td>10%</td>
<td>N/A</td>
<td>14%</td>
<td>18%</td>
<td>20%</td>
<td>14%</td>
<td>12%</td>
<td>23%</td>
</tr>
</tbody>
</table>

GRADUATE PROGRAM

A total of 258 applications were received for the Fall 1993 term. Out of this, 150 were admitted and 66 accepted the offer of admission. Enrollment for Fall 1993 included 154 S.M., 57 Ph.D., 1 EAA degree candidates for a total of 212. Total minority students: 10 (2 Ph.D., 8 S.M.). Total women students: 27 (1 Ph.D., 26 S.M.). In the Spring 1994 term we received 24 applications. We admitted 12 and 4 enrolled. Four women applied, 4 were admitted, 1 enrolled. No minority applications were received. Enrollment for Spring 1994 included 130 S.M., 60 Ph.D., 2EAA (double degree candidate for S.M. and EAA) for a total of 191. Total women: 23 (2 Ph.D., 21 S.M.). Total minority: 9 (3 Ph.D., 6 S.M.).

<table>
<thead>
<tr>
<th>Degrees Awarded</th>
<th>S.M.</th>
<th>EAA</th>
<th>Ph.D.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer (Sept. 93)</td>
<td>13</td>
<td>0</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>Fall (Feb. 94)</td>
<td>20</td>
<td>0</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Spring (May 94)</td>
<td>37</td>
<td>1</td>
<td>4</td>
<td>42*</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>1</td>
<td>17</td>
<td>88*</td>
</tr>
</tbody>
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*(double degree awarded)
FUNDING

<table>
<thead>
<tr>
<th></th>
<th>Fall 1993</th>
<th>Spring 1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIT Fellows/Tuition Awards</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Outside Fellowships</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>Staff Appointments</td>
<td>128</td>
<td>120</td>
</tr>
<tr>
<td>(Afrapt, Draper Fellow, RA)</td>
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<td>Teaching Assistants &amp;</td>
<td></td>
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<td>Teaching Fellows</td>
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<td>9</td>
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<tr>
<td>Engineering Internship Program</td>
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<tr>
<td>Other Types of Support</td>
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<td>32</td>
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<tr>
<td>(Employer, Foreign, Self, Traineeship)</td>
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<td></td>
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<tr>
<td>Total</td>
<td>212</td>
<td>191</td>
</tr>
</tbody>
</table>

FACULTY NOTES

Professor Kenneth S. Breuer was selected as an Ester and Harold E. Edgerton Assistant Professor for a three year term.

Professor Eugene E. Covert was elected an Honorary Fellow of the American Institute of Aeronautics and Astronautics.

Professor Edward F. Crawley was elected a Fellow of the American Institute of Aeronautics and Astronautics.

Professor John J. Deyst joined the Department as a Full Professor on March 1, 1994, was appointed the Jerome C. Hunsaker Professor for one year, and replaced Professor VanderVelde as Head of the Instrumentation, Control and Estimation Division of Instruction.

Professor Mark Drela was promoted to Associate Professor with Tenure effective July 1, 1994.

Professor Eric Feron joined the Instrumentation, Control and Estimation Division as a Charles Stark Draper Assistant Professor on November 1, 1993.

Professor David A. Gonzales joined the Mechanics and Physics of Fluids Division as a Charles Stark Draper Assistant Professor on July 1, 1993.

Professor Nesbitt W. Hagood IV received the American Society of Mechanical Engineering Material Systems Best Paper Award.

Professor Steven R. Hall was promoted to Associate Professor with Tenure effective July 1, 1994, and was elected an Associate Fellow of the American Institute of Aeronautics and Astronautics.

Professor R. John Hansman received the American Institute of Aeronautics and Astronautics Losey Atmospheric Sciences Award for 1994 for "outstanding scientific, engineering and leadership contributions over a broad range of aviation related disciplines which have contributed substantially in the mitigation of aviation weather hazards."

Professor Daniel E. Hastings was elected an Associate Fellow of the American Institute of Aeronautics and Astronautics. He was on sabbatical for the Academic Year.

Professor Walter M. Hollister was on sabbatical for the Academic Year.

Professor Jack L. Kerrebrock was appointed Chairman of the National Research Council's Aeronautics and Space Engineering Board effective July 1994.

Professor Paul A. Lagace was promoted to Full Professor, elected an Associate Fellow of the American Institute of Aeronautics and Astronautics, elected President of the International Committee on Composite Materials, and appointed chairman of the newly formed Department Undergraduate Committee.

Professor Hugh N. McManus was selected by the Provost for a three year appointment as the Class of 43 Career Development Professor.
Professor Dava J. Newman joined the Humans and Automation Division as a Charles Stark Draper Assistant Professor on September 1, 1993.

Professor James D. Paduano was selected as the Carl Richard Soderberg Career Development Professor in Power Engineering for a two year appointment.

Professor Jamie Peraire joined the Mechanics and Physics of Fluids Division on September 1, 1993 as an Associate Professor with Tenure.

Senior Lecturer Joseph F. Shea retired from the faculty.

Professor Leon Trilling retired from the faculty in June 1994. He will continue post-retirement activity in the Department and the Science, Technology and Society Program.

Professor Wallace E. VanderVelde retired from the faculty in June 1994 and will continue teaching in the Department.

Professor Sheila E. Widnall started a leave of absence to serve as the Secretary of the United States Air Force.

Professor Laurence R. Young returned from a leave of absence as a NASA Payload Specialist and took over as Director of the Massachusetts Space Grant Consortium.

MASSACHUSETTS SPACE GRANT CONSORTIUM
Director: Professor Laurence R. Young

The Massachusetts Space Grant Consortium now includes MIT, Tufts, Wellesley, Harvard/Smithsonian Astrophysical Observatory and the Charles Stark Draper Laboratory. The Wright Center at Tufts is responsible for education of pre-college teachers in space science and engineering, through summer workshops. The Program continues to support undergraduate research through the MIT Undergraduate Research Opportunities Program. It increased the number of companies involved in placing students for summer employment in the aerospace industry, supported students for the summer at the NASA Space Academy and the International Space University, and offered graduate fellowships. It sponsored a popular undergraduate seminar subject on "Modern Space Science and Engineering" with emphasis this year on humans in space and several astronaut guest speakers. The annual public lecture this year was given by Dr. Louis Lanzerotti of AT&T Labs, Chairman of the Space Studies Board of the National Research Council.

RESEARCH HIGHLIGHTS

AERONAUTICAL SYSTEMS LABORATORY (ASL)
Director: Professor R. John Hansman

The ASL has been involved in developing advanced alerting and flight information systems for aircraft, helicopters, and spacecraft. In these efforts, the lab attempts to integrate classical aeronautical engineering disciplines of instrumentation, control, and flight dynamics with the evolving techniques of "human centered design" and cognitive engineering. The laboratory also conducts fundamental research in flight safety related areas such as the physics of aircraft ice accretion. The laboratory has developed rapid prototyping techniques which employs graphical workstation technology to evaluate advanced cockpit information systems. Recent or current activities include: advanced alerting of weather and terrain hazards, mode awareness in advanced Flight Management Systems, electronic display of high density chart information, GPS based taxi guidance, synthetic vision systems, flight guidance methods to minimize community noise impact minimal noise impact, and air-ground datalink of ATC clearances.

COMPUTATIONAL AEROSPACE SCIENCES LABORATORY (CASL)
Director: Professor Jaime Peraire

Professor Peraire, working in the areas of computational fluid dynamics, and Professor Gonzales, whose interests are in rarefied flows, joined CASL over the past year. A new program of research focused on the development of a distributed flow simulation environment has been established. The main thrust of this research is to integrate the various areas of expertise within CASL into a unified multidisciplinary capability that can be used for research, teaching and design. Research continues in the areas of aircraft wing optimization, plasma physics, parallel computing and flow visualization.
FLIGHT TRANSPORTATION LABORATORY (FTL)
Director: Professor Robert Simpson
(1) Interactive Adaptive System for Automated Spacing of Aircraft.
(2) Advanced Air Traffic Management Studies.
(3) Design and Development of a Multi-Model Traffic Simulator
(4) A Dynamic Approach for Air Traffic Flow Management
(5) Integration of Airborne Hazard Alerts in Advanced ATC Environments
(6) A Review of the Wake Vortex Research Program
(7) Models for Commercial Air Service in a Multi-Airport region.
(8) Seat Inventory Management for Delta Airlines.

FLUID DYNAMICS RESEARCH LABORATORY (FDRL)
Director: Professor Kenneth Breuer
The FDRL is active in research concerning fundamental issues in fluid dynamics and aerodynamics. Current research projects include: an experimental investigation into roughness-induced boundary layer transition; the control of turbulent boundary layers using active wall motion to reduce drag and turbulent noise generation; the development of micron-sized shear-stress, pressure and velocity sensors for measurement and control of high Reynolds number, sub- and supersonic aerodynamic flows; analysis and simulation of the mechanics of fluids in micron-sized geometries; the development of theoretical models for the dynamics of near-wall turbulent flows; large-scale numerical simulations of unsteady transitional and turbulent shear flows; experiments and modeling of ice accretion on airfoils.

GAS TURBINE LABORATORY (GTL)
Director: Professor Edward Greitzer
The GTL was an all time high of forty students for AY 93-94. The focus of the multidisciplinary research program on "Smart Engines", which is roughly 25% of GTL's overall effort, is moving closer to directly addressing control of instability in advanced high speed turbomachinery. Using the GTL helicopter gas turbine engine test stand, the transfer function and the ambient disturbance level characteristic of an engine environment have been examined. An ongoing collaborative effort with an engine manufacturer involves not only fluid modeling but also analysis of unsteady flow data from their high speed machines. The GTL was the host for a university/government/industry workshop, sponsored by the Army Research Office, on "Intelligent Turbine Engines for Army Applications". A new Aero-Environmental Research Laboratory has been set up in building 31. GTL is also expanding efforts to leverage our resources and make use of unique facilities that exist within other organizations such as United Technologies Research Center, General Electric Aircraft Engines, NASA Lewis Research Center, and Cambridge University, as well as data from such sources as the Air Force Aero Propulsion and Power Laboratory and Pratt & Whitney Aircraft.

LEAN AIRCRAFT INITIATIVE (LAI)
Director: Professor Stanley Weiss
In conjunction with the Center for Technology, Policy and Industrial Development and Sloan School faculty, and funded by the Air Force and 21 aerospace companies, the LAI project's goals are to define the major change agents in acquisition, development, manufacture and related government and supplier regimes which can dramatically improve cost, schedule and quality in the U.S. aircraft industry. After approximately one year of the full program, there appears to be high acceptance of early findings and progress, with sponsors already initial payments for the second year.

MAN VEHICLE LABORATORY (MVL)
Director: Dr. Charles Oman
In October, students and staff in the MVL conducted more than six different biomedical experiments on the very successful STS-58 (Shuttle/Spacelab Space Life Sciences 2) mission. Activities included crew training and preflight baseline data collection both on the ground and in parabolic flight. Professor Laurence Young returned to MIT after serving as SLS-2 Alternate Payload Specialist. Professor Dava Newman joined the faculty after a year at the University of Houston. She is setting up an active program of research on EVA dynamics and the biomechanics of human locomotion. MVL's programs on spatial disorientation and expert systems continue, and new research programs on helmet mounted displays and on the human factors of GPS displays for general aviation aircraft were begun. Dr. Oman was selected as a PI for the 1998 NASA/NIH Neurolab shuttle mission.
SPACE ENGINEERING RESEARCH CENTER (SERC)
Director: Professor Edward F. Crawley

Reflight of SERC's Middeck 0-gravity Dynamics Experiment (MODE) was successfully completed in March on the STS-62. The experiment collected invaluable data on how gravity changes the modal behavior of space structures. The MODE Dynamic Load Sensor (DLS) experiment also measured the forces and moments resulting from crew motions, which will degrade a micro-gravity environment such as that of the International Space Station Alpha (ISSA). The DLS experiment was recently selected to fly on MIR in 1995. The MIR and STS-62 results will be used in the design of the ISSA rack isolation systems. Preparations for the scheduled flight of the Middeck Active Control Experiment (MACE) on STS-67 in January 1995 are underway. Phase I funding was received for the Stellar Interferometer Tracking Experiment (SITE) Space Shuttle flight experiment to be performed with NASA's Jet Propulsion Laboratory. The SITE instrument is a two-aperture stellar interferometer whose objective is to validate in the space environment for the detectors and control systems necessary for future space-based telescopes.

The MIT/NASA distributed piezoelectric active aeroelastic wing was delivered to NASA Langley Research Center in January 1994, and open-loop system identification tests were successfully completed in March. Closed-loop tests, to determine the effectiveness of using distributed piezoelectric actuators to extend the flutter boundaries of aircraft, are scheduled for September 1994. SERC's effort in active materials has involved development of shape memory ceramic materials, modeling and testing of electrostrictive and piezoelectric materials, development of solid state motor technology for high torque density rotary applications, and development of piezoelectric fiber epoxy composites. The latter are currently being applied to active rotor blade development in a cooperative program with Boeing.

SPACE POWER AND PROPULSION LABORATORY (SPPL)
Director: Professor Manuel Martinez-Sanchez

The SPPL continued this year developing theory and models of space propulsion and power systems and their interactions with the spacecraft. Nine graduate students and one Post Doctoral affiliate are currently active in the SPPL. Research topics include electric thruster plume modeling, dynamics of plasmas from gas releases, evaluation of alkali metal seeding in a hydrogen arcejet, application of a SPPL model of solar array arcing to the PASP+ and SAMPIE flight experiments, data analysis of the CHAWS test flight, development of visualization tools for plasma and flow simulations (in cooperation with CASL), Particle-in-Cell 2-D model of a Hall thruster, refinement of an advanced arcej code and computational modeling of several space plasma experiments. A collaboration has been initiated with the Center for Space Research on a future gamma ray burst mission using electric thrusters for deployment.

TECHNOLOGY LABORATORY FOR ADVANCED COMPOSITES (TELAC)
Director: Professor Paul Lagace

Over 30 students were involved with TELAC during AY 93-94, including 17 graduate students, 16 undergraduates, and a number of students in 16.621/2 Experimental Projects Laboratory subject who performed their projects in TELAC. Major research accomplishments during the year include experimental determination of the effects of impact on the behavior of composite sandwich structure along with the development of a technique to assess residual performance, increased understanding of the phenomenon of delamination in composite materials, development of a model for the flow of gasses in porous composite media, development of a model to predict thermally induced damage in composite space structures, and further study of generic damage tolerance issues in composite structures.

WRIGHT BROTHERS WIND TUNNEL (WBWT)
Director: Professor Eugene E. Covert

The test activities of the WBWT were relatively light in AY 93-94. The principal use has been for six 16.621-2 Experimental Projects Laboratory subject projects and calibration of industrial anemometers. In addition to the Cooperative Highway Research Program, the Air Force Office of Scientific Research is sponsoring a program to evaluate new sources of unsteady aerodynamic excitation, with application to gas turbine engine.

DEPARTMENT AWARDS

UNDERGRADUATE

Henry Webb Salisbury Award: This award established in the memory of Henry Webb Salisbury (33) is given annually to a graduating senior in Course 16 for the highest degree of academic achievement. This year's winners were Erik M. Kline ('94) and Tony N. Pira ('94).
James Means Memorial Prize: For excellence in Flight Vehicle Engineering the recipient was Lawrence S. Schwartz ('94). For excellence in Space Systems Engineering the recipients were Erik M. Kline ('94) and Sanjay S. Vakil ('94).

Admiral Luis De Florez Award: Awarded to undergraduates who have demonstrated "original thinking or ingenuity" in Aeronautics and Astronautics. This year’s winners were David M. Brann ('94), Kevin Gilpin ('94), Lawrence K. McGovern ('94), Chad J. Ohlandt ('94), Tara N. Schivone ('94), and Annalisa L. Weigel ('94).

Unified Engineering Award: For outstanding devotion to and leadership of the team of student assistants in Unified Engineering, as well as skillful organization and planning to achieve smooth operation of the complex Unified Engineering enterprise. This year’s recipient was Amir R. Amir ('93).

Andrew G. Morsa ’87 Award: For demonstrated ingenuity and initiative in the application of computers to the field of aeronautics and astronautics this award was given to Kwatsi L. Alibaruho ('94) and Keith S. Jackson ('95).

Leaders For Manufacturing Undergraduate Prize: Awarded to undergraduate students who have used their project to directly deal with issues that are related to the interaction between manufacturing and engineering, through demonstration of modern manufacturing processes in the execution of their project, or through analysis of the origin of manufacturing errors or error analysis of their data or both. This year’s recipients were B. Matthew Knapp ('95), Christine McManus ('95), Lawrence S. Schwartz ('94), and Stephen Wong ('94).

Yngve K. Raustein Award: To recognize significant achievement by a student in Unified Engineering the recipients were Patricia B. Schmidt ('96) and Dean Sheppard ('96).

Several students were selected for named scholarships based upon their outstanding academic record and contributions to the department:

- Mr. Lawrence S. Schwartz ('94)
- Ms. Sonia Ensenat ('94)
- Mr. Lawrence K. McGovern ('94)
- John F. McCarthy Scholarship
- James Cunningham Scholarship
- James Doolittle Scholarship

GRADUATE AWARDS

Eight graduate students were selected as the Departmental Teaching Fellows.

Amir Amir
Pamela Barry
Haryanto T. Budiman
Kin H. Chan
David L. Darmofal
Dana Keoki Jackson
Lilac Muller
Richard Wickham
Raymond Bisplinghoff Teaching Fellow
Edward Taylor Teaching Fellow
Jerome C. Hunsaker Teaching Fellow
Charles Stark Draper Teaching Fellow
Theodore Von Karman Teaching Fellow
Charles Stark Draper Teaching Fellow
Judy Resnik Teaching Fellow
Charles Stark Draper Teaching Fellow

FACULTY

Professor Stanley I. Weiss received the undergraduate teaching award from the student chapter of the American Institute of Aeronautics and Astronautics.

Professor Ian A. Waitz received the graduate teaching award from the student honor society Sigma Gamma Tau.

Professor Leon Trilling received the advisor award from the student chapter of the American Institute of Aeronautics and Astronautics.

Earl M. Murman
INTRODUCTION
The Department of Chemical Engineering continued to operate at the high level of the last decade during the Academic Year 1993-1994. We believe that both the quality and productivity of our programs continued to improve. During this year our undergraduate enrollments swelled to the highest level in 10 years, while the department maintained our philosophy of using only faculty or lecturers to staff all lectures, recitations and laboratory sections. As a result, faculty/student contact hours remained just below six per week. Simultaneously, the number of teaching assistants in the department continued to decrease because of budget cuts and the need to shift funds to harden faculty salaries.

The department’s educational initiative in computational chemistry was realized with the opening of an electronic classroom with high-end graphics workstations in the department. A three-day workshop in January held by Biosym Corporation inaugurated the use of this commercial software in teaching and research in the department. Presently three subjects (one undergraduate and two graduate) are using computational chemistry methods in teaching and modules are being developed for use in polymer physical chemistry and kinetics and reaction engineering subjects. Professor Gregory Rutledge has been the organizer of this effort and the author of proposals to Biosym and the Coming Foundation that made this initiative possible.

Faculty in biochemical engineering have been active and successful in raising funds for new initiatives in research. Professors Greg Stephanopoulos, Charles Cooney, Bob Langer and Danny Wang from Chemical Engineering and Anthony Sinskey from the Department of Biology have received a $5,000,000 grant over four years from the state of Amazonas, Brazil. The grant will enable MIT to assist in the establishment of a center of biotechnology in Manaus, Brazil and will help train engineers and scientists in biotechnology and bioprocess engineering, assist in technology transfer and conduct supporting research at MIT that is relevant to the Brazilian center. Professor Danny Wang, Director of the Biological Process and Engineering Center (BPEC) funded as an Engineering Research Center by the NSF, has led the efforts of our faculty and faculty in the Biology Department to renew the center for a second 10-year term. Although the paperwork is not yet final, the proposal and site visit received extremely high praise, and renewal for the entire period appears very likely. Although on a larger scale than in other areas, the fund raising efforts of our faculty in biochemical engineering are indicative of the majority of our faculty members. The research activity remains high with almost 200 doctoral and 100 visitors and postdoctoral associates presently being supported by our 30 faculty.

Our graduate programs continue to operate at a high level of activity and to attract the best students from around the world. This year 21 doctoral degrees and 24 master's degrees were awarded from the David H. Koch School of Chemical Engineering Practice. The Practice School continued operation of stations at the West Point, PA manufacturing plant of Merck Sharpe and Dohme and at the Midland, MI plant of Dow Chemical Corporation, while adding a Summer 1994 station at the Army Research Laboratories in Natick, MA. Our entering class of 49 graduate students was funded initially by fellowship support from our industrial fellowship program, from the Practice School fellowship endowment, and from alumni/ae contributions. Implementation of substantial changes in the graduate curriculum occurred during the Fall term. These changes included unit reductions in the core graduate subjects, Thermodynamics (10.40), Analysis of Transport Phenomena (10.50), and Reaction Engineering (10.65), with the expectation that graduate students take a fourth subject in their first term. These changes were implemented to reduce the pressure on incoming graduate students, and to allow them to take a broader selection of subjects. Roughly 90% of the new graduate students complied with the recommendation that they take a fourth subject during their first term. In the spring term, the new Systems Engineering (10.551) subject developed by Professors Paul I. Barton, Gregory J. McRae, and George Stephanopoulos was offered for the first time. Many first-year graduate students and others in the Practice School Masters track took this subject, which added a valuable design/synthesis component to our graduate curriculum. Also in the spring term, advanced classes in two of the core areas (Thermodynamics and Transport Phenomena) were offered.

Fund raising continues to be a significant effort of the department. Besides our active fund raising for graduate fellowship support, which supported 40 incoming graduate students in the fall of 1993, the department received several other notable gifts. As part of the class of 1944 reunion gift, several industrial donors have made contributions to the Alan S. Michael’s Fund. The fund now stands at $250,000 and fund raising will continue in an effort to endow a career development chair in biomedical engineering. A new graduate fellowship also was established in the name of Tae Sup Lee. A new fund raising campaign is just beginning to help fund the renovation of space for the department and for BPEC in buildings 16 and 56. Plans are underway to consolidate many of the chemical engineering faculty interested in biochemical and biomedical engineering in space in these buildings.
In October 1993 the department hosted a symposium and dinner to celebrate the 70th birthday of Ed Merrill. The symposium featured speakers six distinguished speakers who described exciting research in polymers and biomaterials, two areas that Ed has helped pioneer in chemical engineering during his career at MIT. Several other faculty were honored by professional societies. The American Institute of Chemical Engineering recognized George Stephanopoulos with the Computing in Chemical Engineering Award and Ed Merrill with the Charles M.A. Stine Award from the Materials Division of the AIChE. Bob Langer won the Distinguished Pharmaceutical Scientist Award, the highest award of the American Association of Pharmaceutical Scientists; Paul Laibinis was selected for the Victor K. Lamer Award from the Colloid and Surface Chemistry Division of the ACS for his outstanding thesis research; Gregory Rutledge was selected to receive the National Young Investigator Award of the NSF; Adel Sarofim shared the Walter Ahlstrom Environmental Prize given jointly by the Finnish Academies of Technology and the Walter Ahlstrom Foundation; Bob Brown and Bob Langer were elected to the American Academy of Arts and Sciences.

There were no retirements or additions to the faculty during this academic year; no faculty searches were conducted. Maria Flytzani-Stephanopoulos, a Principal Research Associate in the Department, left MIT to take a faculty position in the Chemical Engineering Department at Tufts University. Maria’s research was in the area of catalysis applied to flue gas clean-up.

UNDERGRADUATE EDUCATION
The following table shows the trends in undergraduate enrollment:

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<th>89-90</th>
<th>90-91</th>
<th>91-92</th>
<th>92-93</th>
<th>93-94</th>
</tr>
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<tr>
<td>Sophomore</td>
<td>60</td>
<td>67</td>
<td>96</td>
<td>95</td>
<td>115</td>
</tr>
<tr>
<td>Junior</td>
<td>46</td>
<td>60</td>
<td>72</td>
<td>89</td>
<td>90</td>
</tr>
<tr>
<td>Senior</td>
<td>34</td>
<td>47</td>
<td>58</td>
<td>81</td>
<td>84</td>
</tr>
<tr>
<td>TOTAL</td>
<td>140</td>
<td>174</td>
<td>226</td>
<td>265</td>
<td>289</td>
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Chemical Engineering undergraduate enrollment continues the rapid rise that began with academic year 1987-88. This year's enrollment is up approximately 125% from that time to the present 289. The increase in the sophomore class was particularly significant, and we expect next year's sophomore class to be about the same size as this year's. Although it is gratifying to see chemical engineering as a popular choice for MIT undergraduates, the large class sizes are straining our classroom and laboratory resources.

Chemical Engineering Design
Enhancement of the teaching of design continues to be a central part of our undergraduate program. This year we introduced a new design subject, 10.390, as a junior level elective aimed at providing earlier exposure to design issues to our undergraduates. We plan to continue the inclusion of design in the early stages of the undergraduate curriculum next year by the introduction of sophomore seminars. Our senior level design series, Integrated Chemical Engineering, has been enhanced by the addition of several new modules. These include Statistical Design of Experiments taught by Professors Herbert H. Sawin and Klavs F. Jensen, Chemical Plant Design taught by Professor Paul I. Barton, Metabolic Engineering taught by Professor Gregory Stephanopoulos, Design of Materials taught by Professor Gregory C. Rutledge, and Remediation of Contaminated Wastes taught by Professor Kenneth A. Smith and Dr. Deborah Savage. The addition of these modules and the use of IAP for teaching two modules have helped us to maintain small sections sizes in the design subject in the face of increasing enrollments.

GRADUATE EDUCATION
The following table shows graduate enrollment (in the fall of each year) from 1989-1994:

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<th>89-90</th>
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<th>91-92</th>
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<tr>
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<td>164</td>
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<td>159</td>
<td>147</td>
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<tr>
<td>TOTAL</td>
<td>220</td>
<td>223</td>
<td>201</td>
<td>210</td>
<td>209</td>
</tr>
</tbody>
</table>
The total for 1993-94 includes 78 foreign students, 44 female students, and 10 minority students (not including Asian Americans). Graduate admissions data suggest that graduate enrollment will remain in the low 200s for the next several years. The Graduate Committee, under the direction of Professor Robert E. Cohen, has made several substantive changes this year concerning the doctoral program. A stringent timetable for the thesis proposal requirement was enacted; doctoral candidates must submit a thesis proposal within one year after passing the qualifiers. It is expected that early formulation of the proposal, and earlier interactions with the thesis committee will ultimately reduce the residence time for doctoral candidates. Changes have also been made in the procedures for defending the doctoral thesis. Thesis committees now receive drafts of doctoral theses at least one month in advance of the oral defense, and are required to review thoroughly and approve the draft before the student can schedule the thesis defense. The defense itself has taken on a more formal tone, with the addition of a thesis presider (a chemical engineering faculty member other than the thesis supervisor) to chair the proceedings. Defenses now feature open and closed question and answer sessions with the doctoral candidate. In the coming year, faculty committees will be studying procedures and data used in the doctoral qualifying process, and the departmental use of teaching assistants, in hopes of making improvements in these areas. The core curriculum for first year graduate students was restructured beginning this year to provide for more breadth as well as depth in classroom instruction for masters and doctoral students. As part of the curriculum changes, a new subject in Systems Engineering was instituted this year under the direction of Professors Paul I. Barton, Gregory J. McRae, and George Stephanopoulos.

David H. Koch School of Chemical Engineering Practice
This year 39 students participated in the Practice School Program. The two stations, Dow in Midland, Michigan and Merck Manufacturing Division in West Point, Pennsylvania continued to provide a strong basis for operations with excellent projects and recognition on site. To accommodate the increased enrollment this year, a temporary summer station was opened at the U. S. Army Research, Development and Engineering Lab in Natick, MA. Students have also worked at Dow Corning on a few projects to supplement those offered at Dow Chemical. Directors and Assistant Directors for the Practice School Stations were Dr. Thomas Meadowcroft, Director at Merck Manufacturing Division with Vivek Dodd, Victor Antaramian and Jane Ciebien as Assistant Directors; Dr. Barry Johnston, Director at Dow with Victor Antaramian as Assistant Director; Dr. C. Michael Mohr, Director at Natick Labs with Colleen Vandevoorde as Assistant Director. Professor T. Alan Hatton continues to direct the Practice School from Cambridge.

FACULTY NOTES:
Professor Robert C. Armstrong was elected President of the Society of Rheology and began a two-year term in October 1994. He also gave the Professional Progress Award Lecture to the American Institute of Chemical Engineers at their meeting in St. Louis in November.

Professor Daniel Blankschtein became a member of the Editorial Board of Langmuir, a leading journal in the field of Colloid and Interface Science.

Professor Robert A. Brown was on sabbatical leave from April to September 1993. He was the David M. Mason Lecturer in Chemical Engineering at Stanford University in May 1993 and the Centennial Lecturer at the University of Tulsa in February 1994. In spring 1994, Professor Brown was elected to the American Academy of Arts and Sciences.

Professor Linda G. Cima was awarded the Karl van Tassel Career Development Chair.

Professor Charles L. Cooney is co-director of the Program on the Pharmaceutical Industry which was awarded $2.1 million in funding by the Alfred P. Sloan Foundation.

Professor Karen K. Gleason was an invited speaker at the Gordon Conference on Magnetic Resonance in July 1993 and at the 35th Experimental NMR Conference (ENC) in April 1994. She was also selected to participate in the 5th Annual Symposium on the Frontiers of Sciences, sponsored by the National Academy of Science, and to serve on the advisory board for the Department of Chemical Engineering at the University of California at Berkeley.

Professor T. Alan Hatton presented a number of invited papers at the AIChE Annual Meeting in November 1993; the ACS Meeting in San Diego, March 1994 and the Engineering Foundation Conference on Separation Technology in The
Netherlands, July 1993. He is on the organizing committee of two Engineering Foundation Conferences—one on Biochemical Separation, September 1994 and the other on Separation Technology, July 1995.

Professor Jack B. Howard received the Charles L. Hosler Medal of the Pennsylvania State University in recognition of his contributions to coal research. The award was presented at Penn State in April 1994.

Professor Paul E. Laibinis was selected to receive the 1994 Victor K. Lamer Award from the Colloid and Surface Chemistry Division of the ACS.

Professor Robert S. Langer was awarded in the fall of 1993 the Distinguished Pharmaceutical Scientist Award ($10,000)—the highest award of the American Association of Pharmaceutical Scientists. In 1994, Professor Langer was elected a fellow of the American Academy of Arts and Sciences, and a fellow of the Society for Biomaterials. He was selected as the first Feigenbaum Memorial Lecturer at Beth Israel Hospital and Harvard Medical School and was named the Miles Lecturer at Cornell University. Professor Langer was also elected President of the Eleventh Congress on Blood Substitutes and Immobilization Biotechnology and the Chair of the College of Fellows of the American Society of Biological and Medical Engineers. He gave the keynote lectures at the U. S. Food and Drug Administration meeting on Chemistry and Microbiology, and the National Institute of Health Conference on Bioengineering.

Professor Gregory C. Rutledge was named the Joseph R. Mares Assistant Professor of Chemical Engineering and received the National Young Investigator Award of the National Science Foundation. In addition he gave an invited lecture at the Modeling and Simulation seminar co-sponsored by IBM and Biosym Technologies in Boston, MA, and organized a three-day workshop for the department on the use of molecular simulation in research and education.

Professor Adel H. Sarofim was a co-recipient of the Walter Ahlstrom Environmental Prize. The Ahlstrom Prize is awarded jointly by the Finnish Academies of Technology and the Walter Ahlstrom Foundation in recognition of a significant technological achievement. Professor Sarofim was also a co-recipient of both the Senior Thermal Engineering and Towend-BCURA Awards of the Institute of Energy.

Professor Gregory Stephanopoulos co-chaired the 1994 Annual Conference of the American Institute for Medical and Biological Engineering (AIMBE). He was also elected Vice President of the AIMBE. He was a co-recipient of the Best Paper Award for 1993 in Computers and Chemical Engineering. Professor Stephanopoulos delivered the keynote address at the inauguration of the Chemical Engineering Program of the Autonomous University of Barcelona, as well as several other lectures at national and international conferences.

Professor George Stephanopoulos received the Computing in Chemical Engineering Award of the American Institute of Chemical Engineering for 1994.

Professor Jackie Y. Ying received an AT&T Foundation Special Purpose Grant last year to design a novel continuous tubular flow reactor for synthesizing novel nanocrystalline aluminum nitride materials. Professor Ying is on the Editorial Board of Journal of Porous Materials. She was an invited speaker at the Engineering Foundation Conference on 'Vapor Phase Manufacture of Materials' in January 1994, and at the JFCC International Workshop on Fine Ceramics in Japan in March 1994.

Professor Daniel I.C. Wang was appointed to the International Advisory Panel at the National University of Singapore. Professor Wang has been invited to be the plenary lecturer at the 3rd Asia-Pacific Biochemical Engineering Conferences to be held in Singapore between June 12-16, 1994.

RESEARCH HIGHLIGHTS:

Intelligent Systems in Process Engineering
Research in this area, centered in the "Laboratory for Intelligent Systems in Process Engineering" (LIPSE) and directed by Professor George Stephanopoulos, emphasizes two major areas: (1) Design and Development of New Products and Processes; and (2) Intelligent Systems in Process Operations Monitoring, Diagnosis, Planning and Control. Significant advances have been made by Professor Stephanopoulos' group in defining the character of the above problems and in developing sound new engineering solutions, which integrate aspects of artificial intelligence (symbolic modeling, logic, pattern recognition,
Machine learning) with systems and control theory, operations research and statistics. Of particular technological importance are the following two large research projects, which exemplify the work carried out at LISPE:

A. "Synthesis of Batch Processes for Specialty Chemicals Production with Minimum Avoidable Pollution."

This work aims at the development of systematic methodologies for the generation of novel processing schemes manufacturing specialty chemicals at the earliest stages of concept formation by chemists. Thus, early screening of potential reaction routes, catalysts, solvents, and processing steps can identify those production routes that offer the best balance between pollution prevention, safety, and economics. A computer-aided design environment supports the methodological aspects and integrates the corporate-wide activities among chemists, process developers, and process engineers. Supported by a consortium of 10 companies, this technology is being tested by development groups on real-world problems.

B. "Intelligent Control Systems."

The desired autonomy of modern-day control systems for specialties production and materials manufacturing defies the abilities of classical linear controllers. To account for nonlinear dynamics, discrete transitions, reliability in the presence of faults, and an expanded set of disturbances, this project is leading to the development of model-predictive controllers with (a) supervisory logic, (b) diagnostic abilities, (c) learning mechanisms, and (d) robust/reliable nonlinear performance. A series of real-world, industrial implementations has shown that the approaches generated in LISPE offer the potential to revolutionize the control of processing/manufacturing plants.

Metabolic Engineering

The emerging area of metabolic engineering is defined as the purposeful modification of metabolic pathways to enhance the biosynthesis of desired products or reduce the formation of undesirable side products. New microbes can thus be constructed with increased yields for existing products, enriched spectrum of resource utilization, or broader capability for new product production. Such strains and the accompanying fermentation technologies will play a central role in the future production of fuels and chemicals mainly for two reasons: First, because of the new capabilities in utilizing rapidly increasing supplies of carbohydrate raw materials, and second, because of the decreasing costs of biotechnologically-derived products that are projected to become competitive with chemical processes as selectivity is further increased through metabolic or pathway engineering. The key issue in a rational program aiming at increasing the yields and productivities of biosynthetic metabolites is the identification of the critical enzymes that most directly impact upon the flow of carbon in a microbial metabolic network. Once such critical enzymes have been located, molecular biological techniques are employed to introduce very specific genetic modifications at precise points of the metabolic network. The above theme of research is becoming an important part of the overall activity in biochemical engineering at MIT and, in particular, Professor Gregory Stephanopoulos' research program. In collaboration with colleagues from the Biology Department, his research group is developing the principles and methodologies of metabolic engineering in the specific context of aminoacid biosynthesis and bipolymer production. In the course of their work they have succeeded in controlling metabolic fluxes at will and directing the flow of carbon toward the formation of desired products. These cellular properties have been optimally exploited in well monitored and controlled fermentation systems yielding world-class performance in terms of achieved yields and productivities. As a further step in developing the paradigm of metabolic engineering, industrial input is being sought in defining targets of opportunity that will establish this field in the production of fuels and chemicals through modern biotechnology.

Full Wafer Interferometry

Under the direction of Professor Herbert H. Sawin, a technique called Full Wafer Interferometry (FWI) has been developed which measures the etching/deposition rate of thin films during plasma processing of microelectronic wafers. This technique uses a CCD camera to measure the modulation of light reflected from the wafer during processing. As the thin film thickness varies, light created by the plasma scatters from the thin film causing an interference that modulates the wafer's reflectivity. By detecting the light with a CCD camera through a bandpass optical filter and analyzing its modulation in time, the etching/deposition rate can be computed. Professor Sawin's group has shown that this technique can detect variations in etching rates as small as 1% within a die or across a wafer. Variations of the etching rate across a wafer are caused by compositional variations within the plasma. The variation in etching rate within a die is caused by feature aspect ratio (lateral dimension to etch depth) dependencies which have been correlated to line-width variations of etching processes as it effects the electronic devices being manufactured. The control of both types of variations is critical in the manufacturing of microelectronics. FWI has been successfully demonstrated on several industrial etchers as an aid for process development and monitoring. This technology has been licensed to Low Entropy Systems, a start-up company formed by a former graduate
DEPARTMENTAL AWARDS
The Chemical Engineering Department's annual awards ceremony was held in Gilliland Auditorium on Monday, May 2, 1994, with Professor and Department Chairman Robert A. Brown presiding. The following awards were presented:

The Dunbar L. Shanklin undergraduate scholarships in Chemical Engineering for 1993/94 to Brett W. Bader, a junior from Albuquerque, NM, and Sherry H. Hsiung, a junior from Emmaus, PA. In conjunction with the Student Financial Aid Office, National Science Foundation undergraduate scholarships were acknowledged for recipients Jesus R. Jordan, a sophomore from El Paso, TX, and Steven T. York, a sophomore from Chickasha, OK. Albert S. Lau, a junior from Naperville, IL, was recognized for his receipt of a Barry M. Goldwater Scholarship, awarded by the Excellence in Education Foundation. The Dow Chemical Company Outstanding Junior Award recipient was Brett W. Bader (see above), for his balanced record of achievement in academics and campus professional and social organizations, as well as work experience. The American Institute of Chemical Engineers Annual Chapter Scholarship Award was given to Esther K.K. Chang, a junior from Ontario, Canada, and member of the MIT AIChE Student Chapter, for her high scholastic performance throughout the first two years in chemical engineering. The Robert T. Haslam Cup was awarded to Kristala L. Jones, a senior from Longview, TX, for outstanding professional promise in chemical engineering. The Roger de Friez Hunneman Prize, the oldest prize in the department (begun in 1927), was awarded to Wai Thong Wong, a senior from Singapore, in recognition of outstanding scholarship and research.

The newly initiated members of Tau Beta Pi, the engineering honorary society for excellence in academic studies, were recognized: Sandra C. Eltringham, a senior from Tucson, AZ; Kristala L. Jones (see above); Daphne Karydas, a senior from Sharon, MA; Shilpi Mehra, a senior from Old Bridge, NJ; Patricia I. Tsao, a senior from Allentown, PA; Brett Bader (see above); Esther Chang (see above); Anna B. Chwang, a junior from Hong Kong; Xiang D. Dong, a junior from Brooklyn, NY; Marcus G. Frank, a junior from Brazil; Shinya Fukuda, a junior from Medford, NY; Yee Chuan Koh, a junior from Malaysia; Bonnie Yu, a junior from Wayne, NJ; Ketaki N. Patel, a junior from Jersey City, NJ; Lee M. Periolat III, a junior from Chesterton, IN; John C. Rhee, a junior from Mountaintop, PA; Justin A. Strittmatter, a junior from Shreveport, LA; and William C. Tran, a junior from Worcester, MA.

The Edward W. Merrill Outstanding Teaching Assistant Award was presented to Eddie Koury, a graduate student from Trinidad, for excellence in teaching in an undergraduate subject. A second place award went to Lloyd P.M. Johnston, a graduate student from Calgary, Alberta, Canada. Chemical Engineering Department Special Service Awards were given to Joao Paulo Aumond, a graduate student from Sao Paulo, Brazil; Nancy J. Zoeller, a graduate student from Houston, TX; Matthew M. DiPippo, a graduate student from Middletown, RI; Christopher J. Dowd, Jr., a graduate student from Wilmington, DE, and Richard C. McKern, a senior from Needham, MA; for their unselfish contributions to the success of departmental activities. The Chemical Engineering "ROCK" Award for outstanding athletics, as voted by the graduate students of the department went to Christopher J. Dowd, Jr. (see above). The Outstanding Employee Award was presented to Elaine E. Aufiero-Peters, an Administrative Secretary in the Chemical Engineering Student Office, for her exceptional service to the department and its students. The Outstanding Faculty Award from the graduate students, was presented to Professor William M. Deen. Undergraduate students in the department presented an Outstanding Faculty Award to Dr. C. Michael Mohr.

ROBERT A. BROWN
INTRODUCTION

“Our Mission is to educate future leaders of a profession in the service of society and to provide the skills and foundation for life-long learning and growth. Research, the excitement of discovery, and the creation of new knowledge are an integral part of our education.”

The year 1993-1994 was focused on the implementation of action items from our Strategic Plan and in support of our Mission.

Last October 1 the Department was reorganized in two major administrative units: The Henry L. Pierce Laboratory and the Ralph M. Parsons Laboratory. This major reorganization supports our spacing foci in environment, infrastructure, information and management. It recognizes the interdisciplinary nature of these problems and seeks to foster interaction among the strong disciplinary groups in the department. Administratively the new organization is far leaner and hopefully more efficient and responsive than other possible structures.

The Parsons Laboratory and the Pierce Laboratory are directed by Professors Harry Hemond and Fred Moavenzadeh, respectively.

Eight disciplinary groups, charged with promoting depth and excellence in the foundations of the profession, have been defined. The groups and their leaders this past year are: Materials and Structures - Professor Oral Buyukozturk; Transportation - Professor Nigel Wilson; Environmental Fluid Dynamics and Hydrodynamics - Professor Chiang C. Mei; Aquatic Sciences - Professor Sallie Chisholm; Information Technology - Professor Steven Lerman; Construction Management - Professors Fred Moavenzadeh and Jerome Connor; Hydrology - Professor Rafael Bras; Geoenvironment and Geotechnical Engineering - Dr. John T. Germaine.

New service and academic structures are also in place. The Undergraduate and Graduate Education Committees have been reorganized and re-energized under the direction of Professors Lorna Gibson and Joseph Sussman, respectively. A Resource Development Committee operates under the guidance of senior Administrative Officer, Trond Kaalstad. Ms. Patricia Dixon, Assistant to the Department Head, is now in charge of personnel and academic matters.

We have advanced considerably in several other dimensions of the Strategic Plan. Resource Development efforts have been blessed by the generosity of many. Particularly, significant gifts by the Ralph M. Parsons Foundation and Mr. Robert Thurber have significantly increased our ability to provide Fellowships to our students. Largely due to the efforts of Professor Dara Entekhabi the department received a large grant from the National Science Foundation to promote and provide Fellowships for students of Hydrology.

Our efforts to diversify our faculty have resulted in the hiring of two underrepresented minorities and one woman to the faculty. These extraordinary individuals are a welcomed addition to our ranks.

Flagship projects for the department have been actively pursued with significant progress and results in some. The Intelligent Vehicles Highway Systems (IVHS) program directed by Professors Ben-Akiva and Sussman has an ongoing effort with the Boston Central Artery project. Professor Ben-Akiva is Principal Investigator. This actively involves other departments and Lincoln Laboratories. An ARPA-Technology Reinvestment Program proposal has been approved that promotes, in partnership with the School of Architecture and Planning, the Design Studio of the Future.

Negotiations are advanced on interdisciplinary programs on the environment in cooperation with the Department of Defense and centered at Otis Air Force Base. Similarly a major Infrastructure activity is being developed with State Agencies and industry.

In the international arena MIT signed a Memorandum of Understanding as a framework for cooperation with the National Research Council of Italy. The first sponsored research is expected at the beginning of 1995. Finally a large scale long-term education and research effort is being prepared in cooperation with the Province of Mendoza, Argentina.

Finally, this past year began with a couple of successful and extraordinary events. First, the Industry Forum brought together world leaders of commerce, government and academia to MIT last September. The department had extraordinary representation in the leadership of the effort and among the participants. Second, our Visiting Committee met last November.
They expressed satisfaction with the self evaluation and future directions outlined in our Strategic Plan and focused our attention in a few items for the next couple of years.

UNDERGRADUATE EDUCATION

This year we received accreditation by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET) for both our undergraduate programs. The Civil Engineering degree program is experiencing some healthy growth with enrollment of 47 last year, projected to 55 next year. The Environmental Engineering Science degree continues to establish itself as the premier environmental major. The enrollment now stands at 80 with 68 projected for next year.

For the first time the department now offers two minor programs associated with each of its two degrees. Already 12 MIT students are taking advantage of this opportunity representing a variety of departments: Mechanical Engineering, Architecture, Material Science and Engineering, and Chemical Engineering.

A reorganization of course 1.00 Introduction to Computers and Engineering Problem Solving addressed resources and staffing for this major service activity. Over 365 students took this course last year.

The Civil Engineering degree curriculum has been adjusted and revised to strengthen design and team experiences. A new Civil Engineering Clinic, modeled after our successful Environmental Engineering Clinic, will be offered next year. These clinics place students in local firms to develop, work on and solve real engineering problems.

Our undergraduates successfully participated in the fourth annual Waste-Management Education and Research Consortium (WERC) International Environmental Design Contest held on the campus of New Mexico State University in Las Cruces in April. The team of students led by Karen Schmitt '95 (IC) won the Outstanding Team Spirit Award.

GRADUATE EDUCATION

The newly restructured Graduate Education and Admissions Committee had a very active year. Dominating the proceedings was the development of a new Masters of Engineering degree. The concept of an M.Eng. in Civil and Environmental Engineering was one of the key educational initiatives proposed in our Strategic Plan. The degree would be a 9-12 month program emphasizing engineering practice and team work. A common experience and structured curricula are characteristics of the program. The degree is geared to engineering undergraduate degree holders, particularly our own although not exclusively.

The plan is to offer, initially, three educational tracks for the M.Eng. degree: Environmental/Water Quality Engineering, Environmental Geotechnology, and Information Technology. The program has received initial approval by the Committee on Graduate School Policy (CGSP) and our target is to receive our first class in September 1995.

Our reorganization called for and presented the opportunity to revamp our graduate admissions process. We seek to increase our pool of applicants and maintain and improve our selectivity. For some years the number of graduate students in our programs have been in a steady increase. This has created an unreasonable stress on our faculty. We are seeking to better control the number of students in our research oriented masters and doctoral program. The M.Eng. program will permit some net gain in graduate enrollment without undue burden on faculty.

Following are a few tables of enrollment and history of degrees awarded.

<table>
<thead>
<tr>
<th>Year</th>
<th>Faculty</th>
<th>Undergraduates</th>
<th>Graduate Students</th>
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<tr>
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<td>100</td>
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<td>369</td>
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Graduate Degrees Awarded 1989-1994

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<th>Civil Engineer</th>
<th>Ph.D./Sc.D.</th>
<th>Yearly Total</th>
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<tr>
<td>1989-90</td>
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<td>1</td>
<td>32</td>
<td>94</td>
</tr>
</tbody>
</table>

FACULTY NOTES

As of July 1, 1994, there will be 34 faculty members in the Department. Professors Morel, Sriram, Bernstein, Triantifillou and Krumholz resigned from the faculty. Joining the faculty this year are Professors Eltahir, and Patricia Culligan-Hensley. Professor Eltahir is a hydrologist with interests on land-atmosphere interactions, and hydrometeorology. He holds graduate degrees from the National University of Ireland, MIT-Meteorology and MIT-Civil and Environmental Engineering. Professor Culligan-Hensley’s interests are in geotechnical engineering, in particular flow of contaminants in porous media. She is an experimentalist with experience in centrifuge technology. She comes to MIT with a doctoral degree from Cambridge University and experience in the University of Western Australia. Mr. Feniosky Peña-Mora has accepted an offer to join the faculty in July 1995 after a post doctoral experience. Feniosky’s work is information technology and the use of the computer and databases as an aid in conflict resolution during design.

On sabbatical last year were Professors Lynn Gelhar, Jerome Connor, Daniel Roos and David Marks.

Dr. Eric Adams continues running the successful Environmental Engineering Clinic for undergraduates with 24 students participating in industry-based work throughout the term.

Professor Cynthia Barnhart was named to the Mitsui Career Development Chair, which recognizes excellence and promise in junior faculty members whose work can impact and improve the way in which industry operates.

Professor Moshe E. Ben-Akiva continues to serve as the Co-Director of the MIT IVHS Research Program and as the Co-Principal Investigator of a large research activity intended to prepare the Boston Central Artery project for future IVHS advances and implementation.

Professor Rafael L. Bras received the Huber Research Prize of the American Society of Civil Engineers during its annual meeting last October. A new edition of his book, Random Functions and Hydrology, (with I. Rodriguez-Iturbe) was published in October. He continues as Associate Director of the Center for Global Change Science.

Professor Oral Buyukozturk led the Materials and Structures group. He was awarded the Fellow distinction by the American Concrete Institute (ACI). He also edited a special ACI volume on Interface Fracture and Bond.

Professor Sallie Chisholm continues ad Director of the MIT-Woods Hole Joint Program. This year she co-taught Introductory Biology (7.014) with Professor Boris Magasanik of the Biology Department, introducing basic principles of the Ecological Sciences into the core curriculum of MIT undergraduates.

Professor Jerome J. Connor was a visiting research scholar at the Tokyo Institute of Technology conducting research on Damage Tolerant Structures with Japanese colleagues, and visiting research installations.

Professor Richard deNeufville heads the Technology, Policy and Planning Program and headed the committee that formulated the proposed departmental M.Eng. program.

Professor Emeritus Peter S. Eagleson was honored with the Bowie Medal of American Geophysical Union. This is the highest award given by this international union of geophysicists. He continues to actively research the relationship between vegetation and climate.

Professor Herbert H. Einstein’s research on rock fractures was recognized by the award of the Rocha Medal for the worldwide best Ph.D. thesis in Rock Mechanics to his former student, O. Reyes-West. He directs the Mineral Resources Engineering and Management Program (MREM) and the Mining and Mineral Resources Research Institute (MMRRI).
Professor Dara Entekhabi was named recipient of the Department’s Gilbert Winslow Career Development Chair and also was awarded the Arturo Parisatti International Prize from the Instituto Veneto di Scienze, Lettere ed Arti, with the cooperation of the Institute G. Poleni of the University of Padua, for his work in hydrology. He is also a member of the National Research Council’s National Weather Service Modernization Committee.

Professor Lynn W. Gelhar has been on sabbatical leave at Lawrence Berkeley Laboratory where he was affiliated with the Earth Sciences Division working on problems of radioactive waste disposal and hazardous waste site remediation at the Department of Energy facilities. He recently completed the book, Stochastic Subsurface Hydrology, published by Prentice Hall.

Dr. John T. Geraine has served as leader of the Geoenvironment and Geotechnical Engineering group. He was elected member of the Executive Subcommittee of D18 (Soils and Rock Committee) of ASTM.

Professor Lorna Gibson became Chairperson of the Undergraduate Education Committee and won the Departmental Effective Teaching Award this year. She continues her work on the mechanical behavior of cellular materials; this year she began a new project on porous metals, sponsored by ONR. Cambridge University Press has agreed to publish a second edition of her book, Cellular Solids: Structure and Properties, to be completed next year.

Professor Philip M. Gschwend’s book, Environmental Organic Chemistry, (co-authored with Schwarzenback and Imboden) was published by John A. Wiley and Sons, Inc.

Professor Emeritus Donald R. F. Harleman continued as an active advocate of the use of innovative treatment technology in the Boston Harbor cleanup. He was co-author of a World Bank report on appropriate wastewater treatment technology for Central and Eastern Europe. He was a visiting professor at Nanyang Technical University in Singapore and lectured at the University of Hong Kong and the Asian Institute of Technology in Bangkok.

Professor Harold F. Hemond’s new book, co-authored with former CEE graduate student Elizabeth Fechner (’91), Chemical Fate and Transport in the Environment, was published by Academic Press. He is the coordinator for six research proposals in the Community Assessment portion of the renewal of our NIEHS Superfund program. Professor Hemond was appointed the Director of Parsons Laboratory this spring.

Professor Eduardo Kausel was named the Konrad Zuse Guest Professor at the University of Hamburg in Germany during Spring of 1994. In the Fall of 1993, he was an invited speaker for the Southern Mechanics Lecture Series, with lectures at Tulane University, Rice University, Southern Methodist University, and the Southwest Research Institute.

Professor Charles Ladd became chair last October of the Executive Committee of ASCE’s Geotechnical Engineering Division. The Executive Committee is responsible for 18 technical and administrative committees and hosts annual specialty conferences related to the practice of geotechnical engineering. At MIT, Professor Ladd was the first recipient of the Samuel M. Seegal Prize awarded to a faculty member in business or civil engineering “who, more than any other, inspired students in pursuing and achieving excellence.”

Professor Steven R. Lerman continues to direct the MIT Center for Educational Computing Initiatives (CECI), an interdepartmental research center reporting to the Provost.

Professor Christopher Leung received the Gilbert Winslow Career Development Chair. He was invited to serve on the Editorial Board of the Construction and Building Materials Journal.

Professor Robert Logcher developed new research within the Intelligent Vehicle Highway Systems program and was very active in the curriculum development for the new M.Eng. program.

Professor Ole S. Madsen’s devotion to teaching was honored by the Institute by his appointment as “The Class of 1968 Faculty Fellow in the Margaret MacVicar Faculty Fellows Program.”

Professor David H. Marks continued his duties in building environmental engineering education at the Department and School level. Through the Program for Environmental Engineering Education and Research (PEEER), which he leads, he has been helping to spread environmental literacy throughout the Institute. Through funding from the Kann Rasmussen...
Professor Dennis B. McLaughlin received a citation from the American Geophysical Union for Excellence in Reviewing (for Water Resources Research) and was awarded Martin Environmental Funds for an innovative teaching initiative dealing with groundwater remediation. Professor McLaughlin also chaired an oversight committee to review the scientific case for disposing radioactive waste at the Waste Isolation Pilot Project site near Carlsbad, New Mexico. Professor McLaughlin continues to serve as Associate Director of EPA’s Northeast Hazardous Substances Research Center.

Professor Chiang C. Mei is a member of the Visiting Committee, Institute of Applied Mechanics, National Taiwan University. His book, *Mathematical Analysis in Engineering*, is being published by Cambridge University Press.

Professor Fred Moavenzadeh authored a book entitled *Global Construction and the Environment* which was published by John A. Wiley and Sons. Professor Moavenzadeh became Director of the new Henry L. Pierce Laboratory. He led the Institute efforts during the Industry Summit held at MIT last September 1993, and continues as Director of the Technology Development Program.

Professor Heidi M. Nepf joined the department last summer. She was recently awarded a grant from ONR to study flow structure beneath three dimensional breaking waves. In February she gave seminars at the University of Rhode Island and the University of South Florida on mixing in the upper ocean.

Professor Daniel Roos continues as Director of the Center for Technology, Policy and Industrial Development where he is overseeing major studies on the concept of "lean manufacturing" in the aerospace industry.

Professor Yossi Sheffi finished another very active and successful year as Director for the Center for Transportation Studies.

Dr. S. Shyam-Sunder was promoted to Senior Research Associate. Dr. Sunder was instrumental in two successful educational and research proposals to ARPA’s Technology Reinvestment Program. He continues to participate in the NSF-funded ECSEL education coalition.

Professor Joseph Sussman served as chairman of the Department’s Committee on Graduate Education and Admissions. As co-director of MIT’s Intelligent Vehicle Highway Systems program, he studied various institutional constraints to the effective deployment of IVHS. In railroad research, Sussman continued as the direct of the AAR Affiliated Laboratory at MIT and conducted research in rail service reliability. Professor Sussman serves in 1994 as the chairman of the Executive Committee of the Transportation Research Board, an arm of the National Research Council, the working unit of the National Academy of Sciences and Engineering.

Professor William Thilly heads the Center for Environmental Health Sciences.

Professor Daniele Veneziano has been pursuing research within the umbrella of the new MIT-National Research Council of Italy collaboration.

Professor Emeritus Robert V. Whitman continued his development of the undergraduate class *Introduction to Geotechnical Engineering* by introducing three new open-ended design exercises. He was a featured speaker at the symposium culminating the 30-year long VELACS (Verification of Liquefaction Analyses by Centrifuge Studies) program, and presented the 1994 Earthquake Engineering Research Institute Distinguished Lecture.

Professor Andrew Whittle was selected by the Geotechnical Engineering Division of ASCE as the recipient of the 1994 Arthur Casagrande Professional Development Award and also by the Committee on Society Prizes as a recipient of the 1994 J. James R. Croes Medal for his work on the “Analysis of Deep Excavation in Boston”, (co-authored with Dr. Youssef Hashash and Professor Whitman) published in the *Journal of Geotechnical Engineering*, January 1993.

Professor John Williams and Professor Jerome Connor, together with faculty from Mechanical Engineering and Ocean Engineering, have initiated a process of collaboration and integration of graduate education programs in the general area of Engineering Design Computation in the MIT School of Engineering.
Professor Nigel Wilson led the Transportation group. He also served as Chairman of the Institute's undergraduate Committee on Academic Performance.

This year Mr. Trond Kaalstad, Senior Administrative Officer, was honored with the Institute's Murphy Award for his many years of extraordinary service to the Institute, but in particular his dedication to students and their well being.

DEPARTMENTAL AWARDS AND OTHER SPECIAL RECOGNITION
A number of undergraduates received awards and special recognition.

Cheston Buchanan '94 (IA) was awarded the 1993-94 List Foundation Fellowship to support the writing of his novel, *Pike*.

Chen Hui Rosa Chen '94 (IA) received the Joseph D. Everingham Award in recognition of a single creative accomplishment in theater arts by a graduating senior.

Roderick B. Diaz '95 (IC) was awarded the Leo '24 and Mary Grossman Award in recognition of his strong academic achievement and a strong interest in transportation.

Hillary R. Hudis '94 (IE) received the William L. Stewart, Jr. Award in recognition of her outstanding contribution to extracurricular activities and events during the preceding year at MIT.

Benjamin R. Jordan '95 (IE) received the Jeffrey L. Pressman Award to support outstanding research and/or internships in law, government, or public policy.

Paul M. Moody '94 (IC) was initiated into Tau Beta Pi, the Engineering Honorary Fraternity, in recognition of distinguished scholarship in engineering and exemplary character.

In addition, Paul M. Moody and Michael M. Collins '94 (IE) received the Richard Lee Russel Award given to outstanding seniors entering graduate study in civil and environmental engineering.

Karen Nutt '94 (IE) was initiated into Phi Beta Kappa in recognition of scholarly attainment in the liberal arts and sciences.

The Steinberg Prize was awarded to Eric Martin '94 (IC) for academic achievement and demonstrated interest in construction management.

The Department is in its second year of participating in an internship program with the Central Artery/Third Harbor Tunnel project. Three undergraduates were selected to participate in the program during the Summer of 1994: Claudia Bull '95 (IC), David Carr '96 (IC), and Andrew Romain '96 (IC).

The following graduate students received well deserved recognition:

Amy B. Chan won the Dean A. Horn Award to support marine-related research

David S. Cuthbert received the Karl Taylor Compton Prize in recognition of his outstanding contribution in promoting high standards of achievement and good citizenship within the MIT community.

Dawood Pandor was awarded a graduate student fellowship by The American Concrete Institute Research and Educational Foundation for his ongoing thesis work on fiber reinforced high strength concrete.

T. Michael Toole received the Department's Effective Teaching Assistant Award for teaching the graduate subject Strategy for Engineering and Construction Management.

Edmond L. Toy received the Bernard Rabinowitz Fellowship for excellence in leadership and service in technology and policy.

RAFAEL L. BRAS
The department has embarked on a new professional curriculum which, it is believed, will be pursued by the majority of our undergraduate students. Most students now have the option of staying for a fifth year and receiving simultaneously a bachelor’s degree and a Master of Engineering degree. The first M.Eng. degrees were awarded this year. The five-year curriculum is structured and seamless across the traditional boundary between undergraduate and graduate student, and seamless across the traditional disciplines of electrical engineering and computer science.

Undergraduate enrollment in the department continues to be large. Both electrical engineering and computer science are perceived by our undergraduates as offering exciting career opportunities.

UNDERGRADUATE PROGRAM (Leonard A. Gould)
Enrollment of undergraduates averaged 1,000 in 1993-94, with about 50 percent in the Electrical Engineering Program, 45 percent in the Computer Science Program, and 5 percent in the new Electrical Engineering and Computer Science Program. From the Class of 1996, 303 students were enrolled in Course VI, which was a few less than the preceding year. About 285 students from the Class of 1997 have so far selected Course VI. For that class, the ratio of 6-1 (Electrical Engineering), 6-2 (Electrical Engineering and Computer Science), and 6-3 (Computer Science) students is 1:1:1. Six seniors received the new 6-2 Bachelors degree in May.

The new Master of Engineering (M.Eng.) program began smoothly, with 53 students in the pilot year, 35 of whom have now received the M.Eng. degree. We expect to have around 150 students in the graduate phase of the program next year, the second year of the program.

The following prizes and awards were won by our students:

The Henry Ford II Scholar Award for 1994 went to Tracy E. Adams of Hopkinton, MA.

The Ernst A. Guillemin Project Prizes for outstanding performance on an advanced undergraduate projects in electrical engineering were awarded to David S. Lum of Fayetteville, PA, Dinh-Huyen T. Nguyen of San Diego, CA, and Jeffrey B. Reback of Altamonte Spring, FL.

The Ernst A. Guillemin Thesis Prize for outstanding performance on a Master of Engineering thesis in electrical engineering was awarded to David L. Harris of Ridgecrest, CA.

The David Adler Memorial Thesis Prize for outstanding performance on an Undergraduate Thesis in Electrical Engineering was presented to Gabrielle M. Owen of Shaker Heights, OH.

The Charles and Jennifer Johnson Prize for the outstanding undergraduate theses in Computer Science was presented to David R. Bacher of Bloomington, IN, and Douglas H. Muir of Chatsworth, CA.

The Charles and Jennifer Johnson Master of Engineering Thesis Prize was awarded to Ekrem S. Soylemez of Atlanta, GA.

The William A. Martin Memorial Prize for the best thesis in Computer Science was won by Daniel M. Albro of Cary, NC.

The William A. Martin Memorial Thesis Prize for outstanding performance on a Master of Engineering thesis in computer science was awarded to Jan-Williem Maessen of Parsippany, NJ.

The George C. Newton Prize for the best undergraduate laboratory project was awarded to lab partners Robert C. Miller of Merion Station, PA, and Mika Nystroem of Stockholm, Sweden.

Robert M. Fano UROP Awards were given to Hee Y. Kim of Elmhurst, NY, and Daphne Y. Shih of Flushing, NY.
The BNR Project Prizes were awarded to Craig A. Andera of St. Paul, MN, Victor E. Chin of Marietta, GA, Michelle C. Jen of Manchester, MO, Eliott J. Mason, III of Los Angeles, CA, and David S. Warren of Santa Cruz, CA.

The David A. Chanen Writing Award for the best Computer Science paper used to satisfy the second phase of the Writing Requirement went to Eric J. Ding of Cupertino, CA.

**GRADUATE PROGRAM** (Frederic R. Morgenthaler)

In September, 1993 there were 763 graduate students enrolled in the department. About 20 percent of the total were foreign nationals. The department supported 388 Research Assistants and 106 Teaching Assistants. In addition, there were 150 fellowships including 47 National Science Foundation Fellows, 5 Hertz Fellows and 14 Office of Naval Research Fellows. The remaining students had industrial or foreign support or were using their own funds.

During 1993, the department awarded 188 Master of Science degrees, 12 Electrical Engineer degrees and 60 Doctoral degrees.

The department received 1800 applications for the 1993-94 year, a slight decrease from 1992. The applications continue to be generally excellent and 248 were admitted for 1993 (February, June and September), of whom 123 registered in September.

A number of awards were made to graduate students for excellence in teaching. Deron K. Jackson of San Mateo, CA, received the Carlton E. Tucker Award and Kathleen E. Wage of Hendersonville, TN, received the Harold L. Hazen Award. The Frederick C. Hennie III Awards for excellence in teaching were presented to Mark G. Duggan of Lynnfield, MA, Haralabos C. Papadopoulos of Thessaloniki, Greece, and David R. Shoemaker of Killen, TX. The Goodwin Medal was presented to John R. Buck of Somerville, MA. Andrew C. Singer and Carl A. Waldspurger were promoted to Instructor-G in recognition of their demonstrated teaching abilities and services to the department.

**VI-A INTERNSHIP PROGRAM** (J. Francis Reintjes)

In its 77th year, the department’s VI-A Internship Program continued its popularity and excellent performance. During this year’s selection process the number of sophomores who applied was 147 and 77 students were selected as members of the incoming VI-A class. These numbers were comparable to last year’s (135 applications and 81 selections) and even though the number of applications have decreased since the implementation of the M.Eng. program (200 applications and 81 selections in 1992, just prior to M.Eng. program), as long as the number of qualified student applications exceeds the number of available positions, there is no problem.

In September, 1993 Kevin J. O’Toole retired from MIT after serving as VI-A Director for six years. Professor J. Francis Reintjes, a former Director of the program, was appointed Acting Director for the academic year. John A. Tucker, who led the program for 18 years, assisted. Professor Markus Zahn, a full professor in the department as well as a 1968 graduate of the VI-A program himself, was appointed the seventh Director effective July 1, 1994. He pledges his enthusiasm and interest to both the students and the VI-A Program so that this prestigious program continues in good stead with mutual benefits to the education program of the students and to the VI-A companies.

Bankers Trust Company in New York, NY and Qualcomm Incorporated in San Diego, CA are two corporations which have been added to our list of participating companies. They have welcomed their first group of students and we look forward to a long and significant association. Bull HN Information Systems Inc. of Billerica, MA, has left the VI-A Program.

On Commencement Day, May 27, 1994, 47 VI-A students received advanced degrees having completed all their Company Assignments and Institute degree requirements. Eleven VI-A students were awarded their Bachelor's degree — many of whom will continue into the graduate M.Eng. phase of the program.

This spring the department innovated a program entitled “EECS Master Works Oral Presentations” whereby students presented outstanding results selected from EECS Master of Engineering and VI-A
theses in seven different sessions. Of the five Master Works winners (out of 19 total presentations), three were VI-A's: Fred M. Basas, Daniel N. Coore, and David A. Lippe. Each winner received a $100 check.

At the annual Department Awards Ceremony held in the Great Hall of the Quincy Market Building in May, two Department Special Meritorious Service Awards were presented to Professor Reintjes and Mr. Tucker. Their contributions to the Department were duly recognized and these Awards were well-deserved. In addition, the following VI-A students were honored at this event: Eric J. Ding received the David A. Chanen Writing Prize; Craig A. Andera and David S. Warren received the Northern Telecom/BNR Project Award.

At the Institute Awards Convocation, VI-A student Craig A. Andera was presented the Harold J. Pettegrov AWARD in recognition of outstanding service to intramural athletics.

VI-A students continue to excel in their studies. Igor D. Gonta received the Robert Leviton Award from the American Meteorological Society; Katerina H. Nguyen was chosen for an Ida M. Green Fellowship; Ben Y. Reis was the recipient of a 1994-95 Microsoft Corporation scholarship and Brian M. Scassellati was awarded the 1994 Bose Foundation Fellowship. Michael T. Decerbo was selected as one of this year's 25 1994 Burchard Scholars which brings together promising juniors and sophomores who have demonstrated excellence in some aspect of the humanities and social sciences as well as in science or engineering.

Academic awards continue to be received by many VI-A students. Eta Kappa Nu, the Electrical Engineering National Honor Society, initiated 82 EECS juniors and seniors of whom 35 were VI-A's (41%). Of 99 School of Engineering students initiated into Tau Beta Pi, the National Engineering Honorary, 29 were VI-A's (29% of the total). Five VI-A students, out of 40, were taken into MIT's Phi Beta Kappa Chapter: Yuk Ho, Agha I. Mirza, Jonathan D. Rosenberg, Brian M. Scassellati, and Marcin O. Szummer.

MICROSYSTEMS TECHNOLOGY LABORATORIES (L. Rafael Reif)
The Microsystems Technology Laboratories (MTL) carry out research in the fabrication and study of small monolithic structures and their use for the implementation of interesting integrated systems from X-ray lenses to VLSI circuits. The expanding and dynamic research program covers solid state devices, integrated circuits, materials for electronic applications, novel process technologies, sensors and actuators, and computer-aided fabrication. The MTL houses three clean room facilities (the Integrated Circuits Laboratory - ICL, the Technology Research Laboratory - TRL, and the NanoStructures Laboratory - NSL), and associated non-clean laboratory space (the Research Group Laboratories - RGL), and the Computational and Communication Network facility. The centerpiece facility of the MTL is the Integrated Circuits Laboratory, a state-of-the-art class-10 clean lab with full capabilities for modern IC fabrication. The lab is operated by a full time technical staff and graduate students.

During the past year MTL and the Microfabrication Laboratory at the University of California at Berkeley have been working closely to implement mechanisms to formally link their facilities to provide joint processing capabilities and to allow the seamless transfer of wafers, processes, and design rules as well as research personnel with the goal of expanding the research capabilities of both institutions. Significant advances have been realized in linking the two facilities, and plans are currently being developed to include additional university microfabrication facilities to the "National Network of Microsystems Laboratories". Successful linking of a broad spectrum of university microfabrication facilities will ensure access to facility specific technologies and processes and provide processing redundancy to assist in the rapid turnaround of experiments. Linking will allow all users greater access to state-of-the-art technologies, provide exposure to varied academic cultures, and generally to enrich the overall academic experience in a highly cost effective manner.

Also during this past year, MTL has developed a World Wide Web server (http://www-mtl.mit.edu/home.html) which provides a number of information resources, including descriptions and information about activities, facilities, laboratories, students, staff, and faculty, and the research programs at MTL. Information that is beyond the boundaries of MIT, and that are provided through the
MTL WWW server include the *Semiconductor Subway*, that provides a link to all manner of semiconductor- and micro- systems related information sources and the *FAB Database*, which has been drawn from a survey of University facilities that was coordinated by the Semiconductor Research Corporation (SRC), and provides a database of facilities which includes data on specific capabilities (equipment sets, standard processes, etc.). Access to the *Semiconductor Subway* and *FAB Database* are important steps in developing a National Network of Microsystems Laboratories as described in the preceding paragraph.

Personnel involved in ongoing research activities at MTL include over 30 faculty, 3 senior research staff, 233 graduate students, 16 post-doctoral fellows, 17 visiting scientists, 35 undergraduate students, 44 technical support staff, and 21 administrative and support staff. These faculty, staff and students represent affiliations including the Departments of Chemistry, Electrical Engineering and Computer Science, Materials Science and Engineering, Chemical Engineering, Mechanical Engineering, Brain and Cognitive Sciences, Civil Engineering, and Physics; the Center for Materials Science and Engineering, the Research Laboratory of Electronics, the Laboratory for Electromagnetic and Electronic Systems, the Laboratory for Information and Decision Systems, the Laboratory for Computer Science, the Center for Space Research, and the Turbulence Research Laboratory. During the 1993-1994 academic year, 30 Ph.D., 35 S.M. and 2 M.Eng. degrees were awarded in conjunction with ongoing research activities at MTL.

Research in MTL may be grouped into three major interdisciplinary, interactive research themes: Microsystems, Nanoscale Technology/Devices, and Manufacturing, and further divided into the following eleven categories:

1. **Integrated Circuits** include analog and digital integrated circuit (IC) design as well as advanced process development for "mixed analog/digital signal" IC applications.

2. **Microelectromechanical Devices** include technologies for micromachining, design of microsensors and microactuators, and the application of these devices to physical and chemical measurements.

3. **Packaging** includes advanced chip assembly and study of passivating properties of different materials in thin film form; and **Power Devices and Circuits** include research in very high frequency power converters, power device performance, and novel fabrication procedures for energy storage devices.

4. **Electronic Devices** include research on novel devices operating in the semi-classical regime.

5. **Quantum-Effect Devices** include novel device structures designed specifically to study and explore quantum mechanical effects arising from carrier interactions with features of sub-100 nm dimensions.

6. **Submicron and Nanometer Structures** include some "nanofabrication" projects that are not directly related to electronic devices. The NanoStructures Laboratory develops techniques for the fabrication of surface structures with feature sizes in the range of nanometers to micrometers, and uses these structures in a variety of research projects.

7. **Modeling and Simulation** covers the use of numerical techniques that solve complex problems of carrier transport and device operations as well as physical problems that arise during materials and device processing.

8. **Fabrication Technology** covers a broad area of processing and device fabrication with two main themes: novel processes for integrated circuit and device fabrication in silicon and compound semiconductors, and fundamentals underlying materials processing effects.

9. **Manufacturing** includes computer-based modeling and simulation of fabrication processes and execution in a realistic fabrication environment; work flow scheduling; process equipment modeling and process control; and microstructure/mechanical property simulation.
(10) **Materials**, with the common theme of growth and characterization of thin films for electronic applications, include research of novel silicon and silicon-germanium epitaxy, the formation of heterostructures in compound semiconductors, polyimides in microelectronics, and the study and control of the crystalline structure of very thin films.

(11) **Optoelectronics** covers a variety of novel structures such as laser diodes, quantum well structures, and distributed-feedback lasers, both in Si and in compound semiconductors.

The MTL facilities are supported in part by members of the MIT Microsystems Industrial Group, whose current members include: Analog Devices, Inc.; AT&T; Digital Equipment Corporation; General Motors Corporation/Delco Electronics; Hewlett-Packard Company; IBM; Intel Corporation; Motorola, Inc.; Polaroid Corporation; and Texas Instruments, and members of the Microsystems Affiliates Program whose members are Airco Electronic Gases and Sony Corporation.

Outreach activities carried out by MTL include a weekly VLSI Seminar Series, MTL Memo Series, and the MTL Quarterly Bulletin. The MTL also publishes a comprehensive annual report.

**FACULTY**

Three new members of the faculty joined the department this year:

Michael J. Hawley received his Ph.D. at MIT. He was named X-Consortium Assistant Professor of Computer Science and Media Technology.

Bernard C. Lesieutre, Assistant Professor of Electrical Engineering, received his Ph.D. at the University of Illinois.

Gill A. Pratt, Assistant Professor of Electrical Engineering and Computer Science, received his Ph.D. at MIT.

Associate Professors James G. Fujimoto, James L. Kirtley, Jr., and Martin F. Schlecht were promoted to Professor. Assistant Professors Lynn A. Stein and David L. Tennenhouse were promoted to Associate Professor.

We are pleased to announce that Professor Markus Zahn agreed to become Director of the VI-A Program.

The department notes with pride the many honors and awards received by our faculty this year:

Associate Professor Martha L. Gray received the Institute’s Harold E. Edgerton Award, given to a junior faculty member for excellence in teaching, research, and service.

Professor Alan V. Oppenheim received the Institute’s Everett Moore Baker Memorial Award for excellence in undergraduate education.

Associate Professor Martin A. Schmidt received the Ruth and Joel Spira Teaching Award.

Associate Professor Leslie A. Kolodziejski was named Esther and Harold E. Edgerton Associate Professor of Electrical Engineering.

Assistant Professor Steven B. Leeb was named Carl Richard Soderberg Assistant Professor in Power Engineering.

Assistant Professor Gregory W. Wornell was named ITT Career Development Assistant Professor of Electrical Engineering.

Professor Harold Abelson was named Class of 1922 Professor of Computer Science and Engineering.

Professor Richard C. Larson was elected a member of the National Academy of Engineering.

Professor and Department Head Paul L. Penfield, Jr. was elected a member of the National Academy of Engineering.
Professor John G. Kassakian was elected member of the National Academy of Engineering.
Adjunct Professor Gunter Stein was elected a member of the National Academy of Engineering.
Professor Fernando J. Corbató was elected a Fellow of the Association for Computing Machinery.
Adjunct Professor Butler W. Lampson was elected a Fellow of the Association for Computing Machinery.
Professor Emeritus Jack B. Dennis was elected a Fellow of the Association for Computing Machinery.
Professor Emeritus Peter Elias was elected a Fellow of the Association for Computing Machinery.
Professor Ronald L. Rivest was elected a Fellow of the Association for Computing Machinery.
Professor Gerald J. Sussman was elected a Fellow of the Association for Computing Machinery.
Institute Professor Mildred S. Dresselhaus was elected Foreign Associate of the Engineering Academy of Japan. She also received honorary degrees from Austria's Johannes Kepler Universitat and the Technion Israel Institute of Technology. She was also named Zachariasen Lecturer by the University of Chicago and Houston Lecturer at Rice University.
Professor Alan J. Grodzinsky was named Distinguished Lecturer in Chemical Engineering by the University of Toronto. He also received the Kappa Delta Prize from the American Academy of Orthopaedic Surgeons.
Professor Richard D. Thornton was elected a Fellow of the IEEE.
Professor Emeritus J. Frank Reintjes received the Department Head's Special Recognition Award for his work on the development of the new M.Eng. degree program and for his work as Acting Director of the VI-A Program.
Institute Professor Hermann A. Haus received an honorary degree from Belgium's Universiteit Gent. He also received the Optical Society of America's Frederic Ives Medal, the Society's highest award for overall distinction in optics.
Professor and Dean of Undergraduate Education and Student Affairs Arthur C. Smith was named an honorary alumnus of MIT.
The Orange County IEEE Computer Society gave its Charles Babbage Outstanding Scientist Award to Professor Arvind.
Professor Jerome H. Saltzer received the Leonard G. Abraham Prize Paper Award from the IEEE Communications Society.
Professor Robert G. Gallager received the IEEE Communications Society's William R. Bennett Prize Paper Award.
Associate Professor Lynn A. Stein received a National Science Foundation Young Investigator Award.
Professor Emeritus Joseph Weizenbaum received the Humboldt Foundation's Humboldt Research Award.
Several members of the faculty were away for all or part of the academic year:
Professor Dimitri P. Bertsekas explored new research directions in the area of high speed data communications.
Associate Professor David K. Gifford worked with biologists on a computational model of biological development.

Professor Shafiria Goldwasser pursued research in cryptology.

Professor Berthold K.P. Horn explored new research areas in spatial reasoning and map interpretation.

Professor Pierre A. Humblet developed and led a group on mobile communications at the new Eurecom Institute in France.

Professor Ronald R. Parker spent the academic year in Germany, where he served as deputy director of the International Thermonuclear Experimental Reactor project and head of its design center.

Professor Erich P. Ippen spent time in Japan and Europe exploring new research in the physics and nonlinear optics of semiconductor microstructures and optical fiber communications.

Professor James L. Kirtley, Jr. worked in Switzerland doing research on large machines and on electric and hybrid vehicles.

Professor Jin A. Kong explored new research areas.

Professor Martin F. Schlecht explored new research areas.

Professor George C. Verghese did research in India on bulk power systems and began writing a book.

Professors Robert S. Kennedy and Jack P. Ruina retired from the faculty this year.

We note with sadness the death on February 20 of Professor Charles Kingsley, Jr. Professor Kingsley received both the S.B. and S.M. degrees from MIT and joined the faculty in 1940. During his career he spent time at General Electric, Boeing, and Dartmouth. Following his retirement in 1970 he continued to conduct research at MIT, including work on the superconducting generator. He was an international authority on rotating machines, magnetic circuits and other power apparatus. He taught widely in the undergraduate curriculum and was the author, with Prof. A.E. Fitzgerald, of a widely used textbook which was recently brought up to date by Dr. Stephen D. Umans. Earlier, he wrote a textbook with Professor Karl Wildes. His books bridged the gap between basic science and engineering practice. They greatly influenced other textbooks in their day and were translated into many languages. He was an avid mountain climber, hiker and general outdoorsman. He climbed the Swiss Alps and the White Mountains, and during the 1950s, 1960s and 1970s was a member of the White Mountain Guide Book Committee of the Appalachian Mountain Club. He was a Fellow of the IEEE.

PAUL PENFIELD, JR.
INTRODUCTION

The academic year 1993-1994 was another excellent one for our department. We were again ranked at the top in the widely read *U.S. News and World Report* survey. Our faculty body was strengthened by the addition of an outstanding new faculty member, Dr. Chris E. Scott who joined us in June 1994. He comes to us from Eastman Chemical Company where he held the position of Senior Research Chemical Engineer in the Performance Plastic Research Laboratory. His area of research is polymer processing.

In June we awarded 40 bachelors degrees, 27 masters and 16 doctorates. Our program of offering fellowships to a large percentage of domestic applicants continues to provide us with an outstanding graduate student body; over two-thirds of our entering graduate student class are domestic.

Our faculty members continue to occupy leadership positions both within and outside MIT. Within MIT, Professor Vander Sande is Associate Dean of Engineering. Professor Kimerling was appointed and serves as Director of the Materials Processing Center, replacing Professor Eagar who has assumed the position of Co-Director of Leaders for Manufacturing. Professor Hobbs is Associate Chairman of the Faculty. Professor Thomas is Director of PPST (Program in Polymer Science and Technology). Professor Rose continues as Director of the Concourse Program, and Professor Latanision continues as Chairman of the MIT Council on Primary and Secondary Education. Professor Kimerling is President of TMS (The Minerals, Metals and Materials Society) and Professor Carl Thompson is 2nd Vice President of MRS (Materials Research Society).

The department is continuing initiatives begun in recent years and is undertaking several new ones. These include a textbook writing initiative, a new undergraduate materials processing laboratory, a computer education initiative, and a new graduate program designed to strengthen interaction of the department and its students with industry. This program, conducted in partnership with the Materials Processing Center, is designated the "Materials Processing and Manufacturing Institute" (MPMI).

UNDERGRADUATE EDUCATION

Our major initiative for the academic year '93-'94 has been the broad introduction of computation into our department's educational program and related activities. While our faculty members have employed computation extensively in their research it has not, until now, occupied a central role in our curriculum. During the spring and fall of 1993, a committee led by Professor Gerbrand Ceder identified needs and goals for our department in the area of computation and formulated a series of recommendations. These were approved by the faculty in December and implementation is now underway. Following are decisions and accomplishments to-date:

- An introductory computer subject will be required of all sophomores entering the department, beginning in 1994.

- A departmental Athena facility with 4 SUN workstations have been installed in Building 8 and private and Athena workstations are being added to the undergraduate laboratories.

- Biosym Corporation and Molecular Simulation Inc. have agreed to support our initiative by donating their visualization and molecular modeling software for teaching use. Starting Fall '94, the software will be used in 3.082, our undergraduate laboratory and in a new course on computational materials science.

- Work is underway to involve computations in all undergraduate core subjects through homework assignments and in other ways. A module to compute phase diagrams, developed by Professor Ceder's group with support from the School of Engineering, will be introduced in 3.00 in the Fall of 1994.

- Electronic communications are being integrated in the department's correspondence. Network access has been installed in all faculty and staff offices. Our department introduced the first departmental MOSAIC home page at MIT to present information to the department and to the outside world.
Our undergraduate textbook initiative continues to make satisfactory progress. A publication agreement has been signed with John Wiley & Sons establishing the series to be known as The MIT Series in Materials Science and Engineering. Two textbooks by David Ragone on thermodynamics and kinetics of materials are essentially complete and in the publication process. The text Physical Ceramics, is expected to be published during the coming academic year. This text is by Professor Yet-Ming Chiang with co-authors Professor Dunbar P. Birnie and W. David Kingery of the University of Arizona. Other textbooks well under way include a text on structure by Professors Allen and Thomas and one on transport phenomena by Professor Julian Szekely.

During academic year 1991-1992 a special task force led by Professor Michael F. Rubner recommended institution of a new materials processing-property laboratory that would stretch across all materials classes and replace the four existing materials specific laboratories. Our faculty agreed, and during the spring and summer of 1992 space and resources were marshaled, and curriculum development work undertaken. A $350,000 educational grant from the National Science Foundation supplemented departmental and School funds devoted to this task. The laboratory was taught for the first time during the academic year '92-'93. Development of the subject was continued during this past academic year, with enthusiastic response from students and faculty involved.

Our undergraduate enrollment remains at historically high levels. Essential to maintaining our undergraduate body are extensive recruiting efforts, including a 3-day Open House, our annual John Wulff Lecture, direct mailings to the freshman class, Freshman Advisor Seminars, and IAP Activities. Our III-B CO-OP Program continues to attract the majority of the undergraduate students in our department. Through this program we have strengthened our interactions with 40 companies and government laboratories while providing summer experiences for our undergraduates which are relevant to their educational development. Needless to say, placement of students during the summer of 1994 was unusually difficult, but nearly all eventually found suitable positions. Our undergraduate body currently comprises 49% women, 2% underrepresented minorities, and 25% foreign students. We awarded 40 bachelors degrees in 1994.

The Student Undergraduate Materials Society (SUMS) continued to be a source of strength for the undergraduate program. SUMS assisted in end-of-term subject evaluations, planned socials, and assisted in tutoring of fellow students. Officers of the society during the fall semester were: David Gomez (President), Keelan Yang, (Vice President), John Guzek (Secretary), and Sean Peterson (Treasurer). New officers elected in spring 1994, are: Erin B. Lavik (President), John Guzek (Vice President), and Elizabeth K. Lai (Secretary and Treasurer).

GRADUATE EDUCATION

After several years of planning, the department formally instituted this year a new master's degree program involving direct linkages with industry. The program, to officially begin in September, 1994, is known as the "Materials Processing and Manufacturing Institute" (MPMI); it is conducted in partnership with the Materials Processing Center. Students enroll for a 15 month master's degree. Approximately half of the time is spent on campus and half doing thesis work on a processing or manufacturing problem at a company site. Supervision is done jointly by a faculty member and a member of the company's technical staff. The program is fully supported by the company where the work is done. When appropriate, portions of the thesis work can be done at MIT or other sites (e.g. a National Laboratory). We anticipate enrollment of approximately 4 students in this program in the fall of 1994.

Under the leadership of Professor Donald R. Sadoway, a group of faculty members is now developing an industrial ecology initiative for consideration by the faculty. Among other things, the proposed initiative will comprise a professional master's degree program emphasizing the relationship between materials and the environment. An aim also is to infuse the curriculum at both the undergraduate and graduate levels with the knowledge of the impact that materials and materials processing have on the world around us.

Under the leadership of Professor Michael Cima the department is also undertaking an in-depth study of biomaterials. A number of our faculty members now work in this area, on implants and dental materials as examples. We believe that, with the concentration of medical expertise in the Boston area, our department could be doing more on biomaterials.
Approximately 24% of our graduate students are women and 3% are underrepresented minorities. The distribution of our students among our six graduate degree programs and their affiliates is little changed from last year. As of February 1994 it was:

<table>
<thead>
<tr>
<th>Degree Program</th>
<th>Percent of Total Graduate Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramics</td>
<td>12%</td>
</tr>
<tr>
<td>Electronic Materials</td>
<td>26%</td>
</tr>
<tr>
<td>Materials Engineering</td>
<td>24%</td>
</tr>
<tr>
<td>Materials Science</td>
<td>10%</td>
</tr>
<tr>
<td>Metallurgy</td>
<td>11%</td>
</tr>
<tr>
<td>Polymers</td>
<td>17%</td>
</tr>
</tbody>
</table>

Three of our students in Materials Engineering were enrolled in the Technology and Policy Program of MIT, and four were enrolled in the Leaders for Manufacturing Program. Half of our Polymer students were enrolled in the Program for Polymer Science and Technology. We anticipate for the fall of 1994 a graduate class of about 180. The program we adopted four years ago of offering one-term fellowships to a large percent of domestic applicants, has been successful. We estimate we will register an incoming class of 35 for the coming fall, 70% of which will be domestic.

Nearly all undesignated gifts to the department are currently being used to fund endowed fellowships (including the Nicholas J. Grant Fellowship, the John F. Elliott Fellowship, the Ronald A. Kurtz Fellowship, the Gilbert Y. Ching Fellowship, the R. L. Coble Fellowship, the Carl M. Loeb Fellowship, the David V. Ragone Fellowship, the H. H. Uhlig Graduate Fellowship, the Stuart Z. Uram Fellowship, the Class of '39 Fellowship, the Department Endowed Fellowship, and a fellowship given by an anonymous donor). During the past year we received a $600,000 grant from Toyota for an endowed fellowship for our new "MPMI" to be discussed below. Our endowed fellowship funds now provide sufficient annual income for one term fellowships for approximately 8 students.

In addition to the above we are the grateful recipients of a number of grants from corporations and foundations to aid our first year students. We have received a large grant from the Starr Foundation which has provided us with up to 16 fellowships each year for a 3 year period. We have fellowship support from a number of corporations including TECHINT and SIDOR. Of course, many students have other outside fellowship support as indicated elsewhere in this report. Of our 25 domestic students expected to enter in the fall of 1994, 13 will be entering on fellowships from our department and from a variety of sources including, NIH, NSF, DOE, LFM, PPST, ONR and the Air Force.

Newly elected members of the Graduate Materials Council (GMC) are: Harold Ackler (Chairman), Kamala Crawley (Vice Chairman), Chris San Marchi (Treasurer), Doug Blom (Secretary), Tracy Burr and Laura Giovane (DCGS Representatives), Tracy Burr (GSC Representative), Eric Werwa (Social Chair), John Matz (Athletic Chair), and Janelle Gunther (MESS Seminars). Officers of the society during academic year 1993-1994 were: Ann Redsten (Chairman), Janelle Gunther (Vice Chairman), Chris San Marchi (Treasurer), Donna Chuang (Secretary) Eric Werwa and Janelle Gunther (DCGS Representatives), Cheryl Klepser (GSC Representative), Harold Ackler (Social Chair), and Ali Farah and Robert Calhoun (MESS Seminars). GMC continued its seminars and monthly socials. It continued to undertake the supervision of the arduous but important task of course evaluations.

Officers of the MIT Student Chapter of the Materials Research Society during the academic year 1993-1994 were: T. A. Venkatesh (President), Andrew Gouldstone and Ingchie N. Kwan (Vice Chairmen), and Kamala J. Crawley (Treasurer). The group organized a series of lectures on Materials Research in Industry, with speakers discussing opportunities in materials research at their respective companies.

The Association of Materials Students Societies (aMaSS) is a coalition of student chapters of three materials professional societies: Materials Research Society (MRS), ASM International/The Materials, Metals & Minerals Society (ASM/TMS), and the American Ceramics Society (ACerS). The association was formed in 1992 with the purpose of increasing the profile of MIT in the professional society of materials research. Membership is offered to undergraduate and graduate students, from all departments of MIT, who are interested in materials. Officers of aMaSS during academic year 1993-1994 were: Arun Seraphin and Patrick Tepesch (Co-Chairmen), Heather Inglefield (Treasurer), and Kathy Chen (Secretary). Newly elected officers of the association are. Andrew Gouldstone and Ingchie N. Kwan (Co-Chairmen), and Kamala J. Crawley (Treasurer).
The Chairpersons of the three student chapters during the academic year were: T. A. Venkatesh (MRS), Laura Giovane (ASM/TMS), and Andrew Kim (ACerS).

**FACULTY NOTES**

Faculty members of this Department now occupy 13 endowed chairs, the chairholders are: Yet-Ming Chiang, Kyocera Associate Professor of Ceramics; David C. Dunand, AMAX Assistant Professor of Materials Engineering; Thomas W. Eagar, POSCO Professor of Materials Science and Engineering; Merton C. Flemings, Toyota Professor of Materials Processing; Linn W. Hobbs, John F. Elliott Professor of Materials; Lionel C. Kimerling, Thomas Lord Professor of Materials Science and Engineering; Uday B. Pal, John Chipman Assistant Professor; Edwin L. Thomas, Morris Cohen Professor of Materials Science and Engineering; Michael F. Rubner, TDK Professor of Materials Science and Engineering; Subra Suresh, Richard P. Simmons Professor of Metallurgy, Harry L. Tulier, Sumitomo Electric Industries Professorship in Engineering; John B. Vander Sande, Cecil and Ida Green Distinguished Professor and Associate Dean of Engineering; August F. Witt, Ford Professor of Engineering.

Term chairs, especially those held by junior faculty members, are of immense value to the holders in building their careers. Faculty from this department currently occupy 3 such chairs, they are: Stuart B. Brown, Richard P. Simmons Associate Professor of Materials Engineering; Gerbrand Ceder, ALCOA Assistant Professor of Mechanical Metallurgy; Michael J. Cima, Norton Associate Professor of Ceramics Processing.

During this academic year, Professor Samuel M. Allen served as a review panelist for the evaluation of applications in the 1994 competition of the National Research Council (NRC) Research Associateship Programs. Professor Peggy Cebe was elected Member-at-Large of Polymeric Materials Science & Engineering Division of the American Chemical Society for 1994-1995. Professor Cebe was also the recipient of an AT&T Research Initiative Award and a U.S. Army Summer Faculty Research Award. Professor Gerbrand Ceder received a Charles Reed Faculty Initiative Award. Professor Joel P. Clark was elected an AT&T Fellow.

Professor Morris Cohen was the Material Research Society's 1993 David Turnbull Lecturer. Professor Thomas W. Eagar received the 1993 William Irgang Award and the 1993 William Spraragen Memorial Award of the American Welding Society, and was also elected AWS Fellow. Professor Merton C. Flemings received the TMS 1993 Bruce Chalmers Award and was elected to the ASM International Board of Trustees. He also serves as Councillor to the Materials Research Society. Professor Kimerling was elected President of TMS and gave the CMR Annual Lectureship at The Ohio State University. NACE International selected Professor Ronald M. Latanision to receive the 1994 W. R. Whitney Award for his contributions to a better understanding of corrosion science. Dr. Robert A. Laudise was The Edward Orton, Jr. Memorial Lecturer at the 96th Annual Meeting of the American Ceramics Society. The Orton lecture is one of the highest honors bestowed by the Society.

Dr. James D. Livingston was elected to the National Academy of Engineers in recognition of his important contributions in developing the relationship between microstructure and the superconducting ferromagnetic and mechanical properties of metals and alloys. Dr. Robert C. O'Handley received the Information Storage Materials Award for his contributions to the understanding of magnetism, particularly magnetoelastic effects in amorphous alloys. Professor Regis M. N. Pelloux received the Albert Sauveur Achievement Award for 1995 for pioneering contributions in the areas of fatigue crack propagation, micromechanisms of deformation and fracture, and quantitative microscopic analysis of fracture processes in structural engineering alloys. He was also made Membre d'Honneur de la Société Française de Métallurgie et de Matériaux, Paris, France. Professor Robert M. Rose was appointed Adjunct Professor of Biomechanics in the Department of Surgery, Tufts University School of Veterinary Medicine and received the Class of '51 Excellence in Education Award for his proposal titled, "From Russia with Love."

Professor Kenneth Russell was elected President of the Alpha Sigma Mu, Materials Science and Engineering Honorary Fraternity. Professor Donald R. Sadoway received the MIT Graduate Student Council Teaching Award for the School of Engineering and an AT&T Faculty Fellowship in Industrial Ecology. Professor Subra Suresh was the Guest of Honor at a Special Reception hosted by the Chinese Academy of Sciences, Shenyang, to celebrate the publication of his book, "Fatigue of Materials," in Chinese. He was elected Fellow ASM International and appointed a Co-Editor of Acta Metallurgica. Professor Julian Szekely received an honorary doctorate from the Institute National Polytechnique de Grenoble and received the TMS Fellow Award. Professor Edwin L. Thomas gave an invited talk at the Royal Society Discussion on Shape and Form in Polymers and was elected Vice-Chairman of the Division of High Polymer Physics, American Physical Society. Professor Carl V. Thompson was elected 2nd Vice President of the Materials Research Society for the 1994 term. He will serve on the
Professor Joel P. Clark established a major research program in Life Cycle Analysis (LCA) of automotive materials and products, working with automotive assemblers in the U.S., Europe and Japan. Professor Morris Cohen was the Co-Chairman of a recently released NSF Panel Report on Atomic Resolution Microscopy. In this study, projections are given for the achievable advances in materials science and technology that could be accessed if imaging resolutions down to 1 Å and below were to be attained. Professor David C. Dunand continued studies of dispersion-strengthened aluminum. He also demonstrated that superplastic deformation in titanium composites is induced by thermally cycling around the matrix allotropic transformation temperature, a discovery leading to a patent application. Professor Thomas W. Eagar developed the first dynamic model of droplet detachment during gas metal arc welding. He demonstrated a new variation of diffusion bonding, "Liquid Infiltration Powder Bonding," which is capable of producing thick joints in advanced alloys and intermetallics. Professor Flemings completed a study on structure formation in rapid solidification of stainless steels; results are relevant to the important technological issue of steel strip casting. A related solidification experiment was carried on board the space shuttle flight of July, 1994. Professor Nicholas J. Grant's Rapid Solidification Spray Deposition Developments Process was selected by DOE-Alcoa as the basis for a major university-industry research program. Dr. John D. Haggerty initiated research programs in growth of oxide single crystals for use as reinforcements of metal and ceramic matrix composites and as high Tc superconductors.

Professor Linn W. Hobbs continued his studies of high-temperature oxidation and sulfidation of metal alloys. He filed a patent application for a Nb-Cr alloy composition exhibiting corrosion resistance over an unprecedented range of oxygen and sulfur partial pressures. In a new initiative in biomaterials in collaboration with Dr. Myron Spector of Brigham and Women's Hospital in Boston results of oxidation studies are being applied to observation of the interface between Ti implants and bone. Professor Lionel C. Kimerling's silicon microphotronics program produced the first silicon light emitting diode (LED) operating at room temperature with a sharp line width (Δλ= 100 Å) at λ= 1.54 µm. He made the first silicon-on-oxide (SOI) LEDs with the same materials system. The SOI materials structures enable optoelectronic integration, since the oxide confines the light in the silicon.

Professor Kirk D. Kolenbrander has recently grown germanium quantum dots embedded epitaxially in a silicon host. His preliminary results suggest that he has maintained the integrity of the germanium dots while growing epilaxial silicon shells around them. This represents the first epitaxial growth of any semiconductor nanocrystallite in a silicon host, and holds promise for opening up the silicon microelectronics materials platform to optoelectronic and photonic applications. Professor Ronald M. Latanision's research, in collaboration with faculty from this department and the department of Nuclear Engineering, is oriented toward the environmental degradation and fatigue in aircraft structural materials and propulsion systems. A focal point is the development of a portable neutron source for neutron tomography that is capable of detecting, by non-destructive means, in-situ early stage corrosion. Dr. James D. Livingston's research involves slip, twinning and
transformation in laves phase. Professor Anne M. Mayes has formulated the theoretical basis for her recent discovery of copolymer melts that exhibit ordering transitions with increasing temperature. She also investigated swelling effects in copolymer solutions by small-angle neutron scattering. Results were compared with scaling predictions for copolymers in the semidilute solution regime. Professor Frederick J. McGarry developed and validated a method to predict certain types of cracking in electronic packages and a new structure for Polaroid film.

Professor Andreas Mortensen completed a study of the mechanics of capillary phenomena in the infiltration processing of metal matrix composites and developed a process for producing microcellular ceramic foams from preceramic polymers. He completed an investigation of the stored energy of cold work particle reinforced aluminum in collaboration with Professor David Dunand. Dr. Robert C. O’Handley showed for the first time that magnetoelastic coupling in thin films exhibits a surface contribution which becomes evident at very small film thickness. These results are of importance in the magnetic recording industry and other users of magnetic thin films. Professor Uday B. Pal successfully engineered the electro vapor deposition process to obtain leak tight bonds between metallic interconnects and the zirconia based electrolyte plates in planar solid oxide fuel cells. He also elucidated the role of the electrochemical transport in FeO containing slags which controls the decarburization of the suspended iron droplets. He designed and developed a novel electrochemical device for inclusion-free refining of molten metals. Professor David I. Paul explained anomalous coercivity in granular and thin film ferromagnetic materials, obtained "phase transition" for magnetic reversal mechanism and hysteresis as a function of the magnetic anisotropy.

Professor Regis M. N. Pelloux compared the high temperature creep performance of two titanium alloys based on the Ti3Al intermetallic phase to a new alloy (Ti-1100). Professor Robert M. Rose identified the magnetic signature of a corrosion pit in formation by comparison of computational models and SQUID measurements on controlled experiments. Professor Michael F. Rubner successfully fabricated thin film light emitting heterostructures based on conducting polymers using a newly developed layer-by-layer deposition process. He also developed a new class of thermochromic polymers with color transitions that are triggered by body heat. Professor Kenneth C. Russell developed a theory for the unusual nucleation processes which occur in non-equilibrium materials such as fine-scale nanostructures in electronic circuits and mechanically alloyed metals and under irradiation.

Professor Donald R. Sadoway obtained promising results with metal anodes in laboratory-scale aluminum electrolysis cells. He performed the first electrochemical synthesis of a compound semiconductor at cryogenic temperatures -- NiSe from liquid hydrogen chloride at -100°C. Professor Subra Suresh developed a general theory for the evolution of plasticity in response to thermal cycling in metal-ceramic layered solids, completed the first direct and in situ measurement of cyclic stress fields ahead of fatigue cracks in polymers, and completed an experimental study which documents, for the first time, intrinsic differences in high-temperature crack growth response in silicon nitride under static and cyclic loads. Professor Julian Szekely developed a mathematical model of bump soldering operations and this model is now being used as part of a major R&D effort by AT&T. Also, he developed a mathematical representation of droplet oscillation in microgravity; these results were used in a space shuttle experiment aboard the shuttle flight of July 1994.

Professor Edwin L. Thomas' investigations into the phase behavior of block copolymers revealed a heretofore undiscovered equilibrium phase. The new phase is closely approximated by a constant mean thickness structure based on the triply periodic gyroid minimal surface (space group No. 230). Professor Carl V. Thompson developed analytic and computer simulations of the effects of strain on grain growth and texture evolution in polycrystalline thin films. He demonstrated that epitaxial Ni films on single crystal Cu on Si have perpendicular magnetization to surprisingly high thicknesses, ≥ 60 Å. Professor Harry L. Tuller demonstrated the ability to fabricate single electrically active grain boundaries, ZnO, developed processing "tools" for photo assisted micromachining of silicon, and continued development of the science and technology of pyrochlore compounds for use in solid oxide fuel cells.

Professor John B. Vander Sande determined the relationship between the composition of mineral particles lodged in the lungs of coal miners who are either healthy or exhibiting pulmonary abnormalities. His work on high resolution electron microscopy revealed a large number of fullerene-like "giant" molecules produced by controlled burning in flames. In other research, he showed that a large magnetic field (≤10T) can have a very strong influence on the texture of superconducting oxides annealed at elevated temperatures in these high fields. Professor August F. Witt's research focus was on using high temperature heat pipes in gradient freeze configuration with axial thermal gradient stabilization. Professor Bernhardt J. Wueensch grew high-purity bicrystals of MgO and NiO with symmetric tilt orientations and thicknesses. In the case of NiO, the epitaxial deposits could be chemically removed from the substrate to provide a free standing bicrystal.
DEPARTMENTAL AWARDS

Bradley J. Begle was invited to join Phi Beta Kappa. The fall initiates for The Tau Beta Pi Engineering Honor Society were: John Guzek, Uday Jhunjhunwala, Sandra K. Joung, Andrew Kim, Erin B. Lavik, Ling Liao, Julie Ngau, William W. Samec Jr., Dorian Balch, Bradley Begle, Stephen C. Britten, Sara Buta, Ann Hirahara, John King, Barbara Nichols, Mary Beth Kossuth, and Anant Setlur.

Three seniors were accepted as associate members in the Society of Sigma Xi, The Scientific Research Society of North America: Stephen C. Britten, Mary Beth Kossuth and Sean F. Peterson.

Stephen C. Britten was awarded one of three 1993 Willy Korf Memorial Scholarships Awards by the Iron and Steel Society, Inc. Darrell Furth was named a 1993 Truman Scholarship finalist by the Harry S. Truman Scholarship Foundation. About 135 students were chosen for the honor among 1,350 candidates nominated by 600 colleges and universities. Andrew Youngkyu Kim and Joyce J. Espiritu were selected as recipients of the 1993 ASM International Undergraduate Scholarship, which is funded by a grant from the ASM Foundation for Education and Research. Surekha Vajjhala was selected as John Ely Burchard Scholar in the MIT School of Humanities and Social Science for 1994. Kenneth Chu-ChaoWu was awarded the N.J. Grant Scholarship

8 graduate students were accepted as associate members in the Society of Sigma Xi: Harold D. Ackler, Jason F. Amaral, Thomas D. Chen, Brian J. Gally, Kevin G. Restier, Charles W. Rowe, Eric Werwa, and David E. Woolley. 10 graduate students were accepted as full members: Steven A. Attanasio, Robert B. Calhoun, Bertha Chang, Heather E. Inglefield, Toshihiko Koseki, Robin B. Michnick, Martin M. Morra, Hichem Msaad, A. N. Sreeram and Benjamin Wu.

Steven Attanasio received the H. H. Uhlig Award from the Boston Chapter of the NACE. Valerie Benezza received an MRS Graduate Student Award. Andrew Chen received the Best Academic Paper at the ASM/ESD Advanced Composites Conference in Dearborn, MI. Jeffrey D. Nystrom was among 12 winners selected by the National Research Council in the first predoctoral fellowship program in integrated manufacturing. Bruce Pint gave an invited talk at the Gordon Conference on Corrosion in New London, NH. Joyce Wong received a Materials Research Society (MRS) graduate student award.

Fellowship Awards for one or more semester were held during academic year 1993-1994 by 54 students: Sang Hoon Ahn, Lord Fellowship; Jason Amaral, TPP Fellowship; Valerie Benezza, ONR Fellowship; Douglas A. Blom, Starr Fellowship; Mark Brillhart, NASA Fellowship and American Chemical Society Fellowship; Caryl Brown, LFM Fellowship; Mayank T. Bulsara, Starr Fellowship; Tracey Burr, Starr Fellowship; Robert Calhoun, SCEE Fellowship; Darren Castro, NDSEG Fellowship; Jimmy Chen, AT&T Fellowship; Kamala Crawley, Starr Fellowship; Scott Deering, AT&T Fellowship; Elizabeth Earhart, NASA Fellowship; Kristi Fukami, Rocca Fellowship; Brian Gally, NDSEG Fellowship; Diana Garcia, GEM Fellowship; Gerardo Garbulsky, Rocca Fellowship and Class of '39 Fellowship; Laura M. Giovane, Starr Fellowship and Claire Booth Luce Fellowship; Jason Gratt, NDSEG Fellowship; Janelle Gunther, US Air Force Fellowship; Isako Hoshino, AT&T Fellowship; Robert Hyers, NASA Fellowship; Cheryl Klepser, NSF Fellowship; Adrian F. Kohan, Starr Fellowship and US Air Force Fellowship; Debra Koker, NSF Fellowship; Devin MacKenzie, Starr Fellowship; Lynn McDonough Chalouf, NSF Fellowship; Alice Man, ONR Fellowship; Patricio Mendez, Rocca Fellowship; Michael Morse, AT&T Fellowship; Orhun Muratoglu, ME Fellowship; Krassimir Noven, EECS Fellowship; Jeffrey Nystrom, DOE Integrated Manufacturing Predoctoral Fellow; F. Patsiogiannis, Rocca Fellowship and Sidor Fellowship; Adam Powell, AT&T Fellowship; David Pratt, NSF Fellowship; Roy Rasera, Starr Fellowship; Anne Redsten, NDSEG Fellowship; Christopher Rice, Sidor Fellowship; Charles W. Rowe, 3M Fellowship; Jeannette Ryan, NSF Fellowship; Thomas F. Schaub, 3M Fellowship; Steven C. Seel, 3M Fellowship; Arun Seraphin, NDSEG Fellowship; John Sprague, Starr Fellowship; Patrick Tepesch, NDSEG Fellowship; Julie Tsai, SRC Fellowship; David Walton, John F. Elliott Fellowship and Loeb Fellowship; Eric Werwa, AT&T Fellowship; Dongsik You, 3M Fellowship; Bo Zheng, An Wang Fellowship

CLOSING REMARKS

I can perhaps be forgiven if I close this report with a look backwards, as I enter my 13th and final year as Department Head. In the fall of 1982, when I assumed the duties as Department Head the ground had been prepared by Morris Cohen, Walter Owen and others on our faculty for our development of a broad based materials department. Nonetheless, we were still largely a metallurgy department. Our faculty body had 39 members, of whom 70% were metallurgists. Today, only about 30% of our faculty body comprises individuals whose primary research focus is metallurgy.
The above numbers tell only a part of the story. In 1982 we had no electronic materials degree program, our polymer work was exclusively on structural polymers including composites, our activities in electronic ceramics were a small portion of our total activities, almost none of which was on thin films. Today, over a quarter of our graduate students are enrolled in our electronic materials degree program, and nearly a fifth in polymers. Our research activities cut broadly across all materials classes. Processing, always a strong suit of this department, has been strengthened in recent years, and is being supplemented by growing activities in manufacturing.

Our academic program has seen much change and, I believe strengthening, over the past decade. Of course, the curriculum now reflects that the department is a materials department. Beyond that, teaching laboratories have been totally modernized and re-directed with the aid of grants from the Balfour Foundation and NSF which totalled $1.4 million, and with much hard work on the part of many faculty members. A series of textbooks is underway, and the new Materials Processing and Manufacturing Institute described elsewhere in this report has much promise for the future.

Since September of 1982 we have hired 25 faculty members, of whom 18 are still on the faculty, including 8 who are tenured. These young men and women are national and international leaders in their fields and we can be justly proud of them and their accomplishments.

Through the generosity of our alumni; friends and corporations we operate today with a far stronger financial base than we had a dozen years ago. Our faculty members hold a total of 15 chairs, 12 of them endowed, whereas in 1982 we had a total of two such chairs. The Department has today endowed funds sufficient to provide 8 one semester fellowships each year. In 1982 we had none. The current award gift and grant stream to this department promises to provide additional future resources.

The decade ahead will be greatly different for our department and for our students from that of the past 40 years. External changes affecting us include decreased international tensions; globalization of information, technology and trade; the changing nature of relationships between the federal government and the research universities; the career opportunities which will be available to our graduates; increased environmental awareness; and changing social structures.

Time will tell how this department will evolve in view of our changing environment. My own view is that we will need to maintain the intellectual base of structure/processing/property/performance that has served us so well for the past decade. But we will need to build on that in new ways, focusing on new issues of technological and societal importance. Two of these are surely industrial ecology and biomaterials engineering. We need to better reflect the diversity of our country in our faculty and student body. We can expect a higher percentage of our graduate students to seek only the master's degree, and we will need to emphasize for them materials engineering, and broader systems aspects of engineering.

In our research activities we can anticipate, and hope for, increased industrial interaction, and increased involvement in interdisciplinary, focused engineering research activities. But we will need (probably often) to remind our sponsors and collaborators that our field encompasses the spectrum of science to engineering, and that we can best serve our students and society by retaining a strong science base which relates to our engineering studies and to industrial and societal needs. Whatever may be the path we follow, we can, I believe, be confident that our field is vital and productive, and that we have the strength and will to maintain our leadership in it.

MERTON C. FLEMINGS
The most important goals of the Department of Mechanical Engineering are to prepare young men and women to be leaders in their chosen fields and to make an impact on the basic knowledge, technology and society through education, scholarship and research. These are challenging tasks. Unlike pure science, the relative importance of a specific technology evolves with time and so must an engineering education. History reveals this evolution. In the early 20th century, this country’s strongest mechanical industries, namely the automotive and machinery industries, were dominant, rapidly changing as mechanical technology advanced. In this environment, talented mechanical engineers prospered and directed these industries. In the last few decades the technological growth has decelerated and other factors such as financing, marketing and law have become increasingly important and have begun to play major roles in this industry. Not only has the technology changed, but more importantly, the pre-requisites to be an industrial leader have also changed. Hence, mechanical engineering disciplines have taken on broader technological approaches. This is one of the reasons we need to broaden the perspectives of our students without sacrificing the rigor of an engineering education.

Although the industrial heydays of the mechanical engineering era may be over, mechanical engineers are thriving, making important technical contributions to many fields of engineering and responding to future societal needs. Design, a core discipline of mechanical engineering and pivotal in all synthesis related disciplines, is emerging as one of the most exciting fields of research. Advances in most aspects of manufacturing rely on mechanical engineering principles; future advances in health care will be possible through the use of micro-surgical robots and micro-submarines that deliver medication to the specific site; transportation will be more efficient and pollution free; longer lasting portable electric power sources will be dependent on our ability to manipulate micro-electromechanical devices; and standard textbooks will be replaced or augmented with an interactive software system. This is a small sampling of some of the areas of research the Department is currently involved in to maintain its leadership position.

The means with which to best achieve the dual goals of a mechanical engineering education is a continuous and evolving process for the Department. Some of the major efforts include the development of a more refined undergraduate curriculum; ongoing searches for new faculty members who are in the forefront of their fields; more emphasis on strengthening our relationships with industry and government agencies; expanding on research activities in new frontiers of engineering, science and technology; the development of new pedagogical interactive media to enhance teaching and learning; and the modernization of teaching and research laboratories to better meet the educational needs of our students. These activities make the Department exciting place to learn and to teach. Its scholastic rigor, intensity, commitment and sense of excellence are the hallmarks of the department’s culture. Furthermore, our faculty take their commitment and dedication to teaching most seriously.

By the end of the academic year 1994-95, more than a third of the faculty in the Department will have joined the Department since 1991. Our goal is to identify the best people who can make an impact on education, knowledge base, and technology base. Engineers, scientists, and applied mathematicians who can take us to the next plateau during the next two decades will have joined the department as faculty members. We hope to have the strongest disciplinary groups to maintain our leading position in engineering systems areas. We feel that we are making major strides in moving the field of mechanical engineering to a newly heightened stage of excellence.

The Department is committed to interdisciplinary education and research programs, many of which are led by our well renowned faculty members. Professor Ian Hunter recently joined the biomedical faculty group and the Newman Laboratory. He is internationally renowned for his work on micro-surgical robotics. Professor Ely Sachs has been expanding his work on 3-D Printing with faculty members from two other departments. Professor Jung-Hoon Chun is collaborating with colleagues in nuclear engineering on a new idea than can identify the solidification front. Professors Mary Boyce, David Hardt and Dr. Andre Sharon are currently collaborating in the field of manufacturing. Professor Ali Argon leads collaborative efforts on materials with many colleagues outside the Department. Professor Anu Annaswamy and Ahmed Ghoniem are working together on controlling the combustion
process in gas turbines. Professor Nam Suh is presently collaborating with surgeons at the Brigham and Women's Hospital in the area of tribology. In addition, many of our faculty are influential, either directly or indirectly with MIT's Sloan School of Management. These are just some of the examples of the types of interdisciplinary projects and broad fields of interest our faculty have been deeply embedded. This cross-disciplinary interface between traditional disciplines and non-traditional disciplines of mechanical engineering are offering us new intellectual opportunities. Our goal is to promote greater synergistic interactions among the faculty, to provide mechanisms for collegiality among a wider circle of colleagues, and to recognize and reward contributions made by the faculty both in disciplinary and systems teaching and research.

The Department is presently undergoing a transition to accommodate budget reductions mandated by the MIT administration. We have used this opportunity to re-examine all aspects of the Departmental functions. The Department formed an ad hoc committee, headed by Professor David Gordon Wilson and composed of administrative, support and faculty members, to recommend steps that we can take to regroup our support staff and teaching funds while still a maintaining the intellectual and educational strengths of the Department. These recommendations are currently being implemented. In this manner, we will continue to become more effective as an organization and strengthen our intellectual and educational endeavors. We hope that any future budget reductions will not force the Department to weaken its core strengths.

The Department has been rated, once again, as the best mechanical engineering department in the United States. The department has earned this distinction through its ability to attract the best students and faculty, to respond to changing societal and national needs, and to lead the profession with innovative ideas and programs in education and research. Over the years, it has created and established strong programs in energy, transportation, information technology, biomedical engineering, manufacturing, and environmental engineering. These achievements were built on the Department's high standard of excellence in the basic disciplines of mechanical engineering, i.e., solid mechanics, fluid mechanics, thermal sciences, materials, control, systems, and design. At the same time, it has expanded the traditional definitions of mechanical engineering through its innovative approach to solving new problems. This tradition of pioneering new scientific and technological frontiers, while remaining firmly grounded in fundamental engineering science, is alive and well in the department. Students' response to the department has been most gratifying. It remains to be one of the largest departments in MIT, with more than ten percent of the Institute's undergraduate and nearly ten percent of the graduate student population.

In addition to examining formal instructional programs, the Department has maintained its initiatives to enhance the learning and cultural environment for all of its students. The goals are to expose the student to contemporary technological and societal issues and to provide them with broader perspectives on their role in society. This is done primarily through the Distinguished Alumni /ae Lecture Series, sophomore picnics, semi-annual letters to undergraduate and graduate students from the department head, and departmental support of student activities.

The department strives to provide a first-rate learning environment for women students. It has several outstanding women professors on its faculty. MEGAwomen (a departmental organization of women graduate students) have been very active in preparing brochures and information packets for incoming graduate students. They have also been instrumental in initiating activities to provide information to women students, to attract more women students into doctoral programs, and to enhance employment opportunities for women students. The department is also committed to hiring more underrepresented minority faculty members.

A major effort is under way for the development and improvement of the facilities and equipment of teaching and research laboratories in the department. The goal is to endow more of the laboratories to ensure continued maintenance and modernization in future years. The AMP Mechanical Behavior of Materials Laboratory was dedicated in April of AY 1993-94 as a result of these efforts. A major commitment was received and the renovations of the design and engineering projects laboratories on the ground floor of Building 3 is well underway. The Pappalardo Laboratory will be dedicated in the late fall of AY 1994-95.

In order to support research projects and initiatives that expand the traditional bounds of mechanical engineering, external fund raising activities are actively pursued by the department for endowed
laboratories, chaired professorships and graduate fellowships. The department has been working with the development offices of MIT to raise funds to further advance undergraduate education, honor a large number of senior faculty members of the department, to attract more outstanding graduate students, and to keep its lead in research. In addition, we have initiated activities to create "Renaissance" professorships to enable gifted faculty members to change their research fields by combining their old fields with a new discipline so that we can create new intellectual and technological frontiers. Our ultimate goal is to name the Department after a major donor.

PROGRAMS OF INSTRUCTION

Objectives

The overall educational objective of the department has not changed in 40 years: to educate people to become leaders in industry, education, research, and public service. To this end, the department provides a strong disciplinary foundation, opportunities to learn interdisciplinary subjects, experience in solving contemporary scientific and technological problems, and intellectual exposure to socioeconomic and political issues.

The cornerstone of the department's educational plan is the strong interaction between distinguished faculty and highly motivated, intelligent students. The goal of undergraduate education is to provide a broad educational background in mechanical engineering to prepare students for changing technological opportunities and societal needs. The graduate program is designed to educate professionals and scholars in the field of mechanical engineering.

Undergraduate Programs

Degree Programs and Enrollment

The department's undergraduate program leads to the S.B. in Mechanical Engineering (Course II) which is accredited by the Accreditation Board for Engineering and Technology (ABET) or the S.B. in Mechanical Engineering without specification (Course II-A), also ABET-accredited. Course II-B (the Engineering Internship Program) leads to the S.B. and S.M. in Mechanical Engineering with industrial experience as an integral part of the program.

Course II-A is intended for those students who wish to design a special program coupling such areas as biomedical engineering, management, or energy policy with mechanical engineering. Approximately 47 students are enrolled in Course II-A. Course II-B averages about 25 students each year. Currently about half of the sophomores entering mechanical engineering continue to a graduate degree.

The department enrollment continues at levels comparable to the past few years, with about 402 undergraduates at the end of the spring term. The enrollment included 119 women and 214 underrepresented minorities.

In 1993-94, the department awarded 114 Course II degrees, 17 Course II-A degrees, and 14 Course II-B degrees.

Undergraduate Curriculum Development

An ad hoc Undergraduate Curriculum Development Committee (Professors Mary Boyce, Jung-Hoon Chun, Woodie Flowers, David Gossard, Peter Griffith, John Heywood [Chair], David Parks [Chair], Carl Peterson, Emanuel Sachs, Warren Seering and Jean-Jacques Slotine) is re-examining the undergraduate curriculum and making recommendations to the department regarding an improved undergraduate curriculum. Its work has generated extensive discussion, although final recommendations have not yet been made.

Several faculty members are currently involved in the ECSEL program. Specific activities under way in this program are projects such as improvement of the effectiveness of undergraduate engineering education and attracting more students to this field. Professors Flowers, Roger Kamm, Robert Mann, Carl Peterson, Simone Hochgreb, Mark Jakiela, Harri Kytömaa, Frank McClintock, Igor Paul, Joseph
Smith, Jr., and David Gordon Wilson are contributors to this effort. The engineering-design instructional computer system (EDICS) continues to grow in popularity and versatility. Interest has been expressed by several mechanical engineering departments around the country in adopting EDICS as a teaching tool.

The design contest associated with 2.70 Introduction to Design continues to gain national and international attention. The international design contest now includes students from four nations.

Faculty have continued work in the development of the core manufacturing subject. An undergraduate manufacturing textbook has been written, and is under revision. A special summer subject based on the core manufacturing subject has been offered through the American Society of Engineering Education for engineering educators so experience in the manufacturing area can be shared among a number of schools. Over 40 schools have sent faculty to this program in two years.

Organization

The Undergraduate Program is administered through the Undergraduate Office. The office is supervised by Professors Griffith (Chair, Undergraduate Committee) and Wilson (Undergraduate Officer). Professor Bora Mikic acts as Scheduling Officer. Together, they are responsible for organizing and coordinating the Undergraduate Program and the scheduling and staffing of undergraduate subjects. The Senior class Registration Officer is Professor Griffith, the Junior class Registration Officer is Professor Peterson, and the Sophomore class Registration Officer is Professor Warren Seering. Professor Thomas Sheridan is the Advisor for Course II-A, and Professor Paul is the advisor for Course II-B. Ms. Peggy Garlick is the Undergraduate Programs Administrator.

Student Organizations

The Student Chapter of the American Society of Mechanical Engineers, under the leadership of its officers Vikran Mehta, President, John Wlassich, Vice President, Maia Singer, Secretary, and Dean Franck, Treasurer, has continued to develop student professional activities in the department. Professor Paul serves as the Faculty Advisor to the 144 members.

Black ME is an organization of students which provides a supportive environment for minorities in the department. Membership continues to be strong with about twenty students. The present leadership comprises Mark Randall, President, Chimbaugona Mkandawire, Vice Presidents, Christee Ballamy, Secretary, Warren Marcus, Treasurer, and Khary Bridgewater and Fritz Francis, Career Officers. Professors Wilson and Suh are the Faculty Advisors.

Pi Tau Sigma, the mechanical engineering honorary society, continues its tradition of fostering student-faculty relations and serving the department through its course and instructor evaluations, and honoring newly-elected members with a spring banquet. The organization is led by Tariq Shaukat, President, Craig Zilles, Vice President, Elizabeth Zapata, Secretary, and Wayne Dempsey, Treasurer. Professor Derek Rowell serves as Faculty Advisor.

The Student Chapter of the Society of Manufacturing Engineers has as President Alan Duros. Professor Timothy Gutowski is the Faculty Advisor.

Graduate Programs

Degree Programs and Enrollment

The department offers the S.M. degree in Mechanical Engineering, the undesignated S.M. degree, the degree of Mechanical Engineer, and the doctoral degree (Ph.D./Sc.D.) in Mechanical Engineering. The undesignated S.M. degree allows students to pursue special interdisciplinary programs as well as programs which are more specialized than those satisfying the designated degree requirements.

Graduate enrollment is 401 full-time students. As of the fall term, the enrollment included 45 women and 45 underrepresented minorities. In September 1993, 229 new students were admitted from 652 applicants, with 114 students registering.
In the fall term, 95 percent of all graduate students received support from the department, MIT funds, fellowships, government, or industry. Of those students, 71 percent were supported by the department through research and teaching assistantships.

In 1993-94 the department awarded 110 S.M. degrees (of which 8 were combined S.B./S.M. degrees). 31 Ph.D., 2 Sc.D., and 1 Mechanical Engineer degrees were awarded.

Graduate Curriculum Development

Efforts continue to develop graduate subjects in the areas of control, manufacturing, and design. Several faculty plan to formally introduce subjects in the next year which are presently offered only as special topics. Four new subjects have been added to the curriculum for next year: 2.159J Computer Aided Engineering I, taught by Professor John R. Williams of Course 1, 2.306 Dislocations and Mechanical Properties of Crystalline Solids, 2.725 Design Optimization and Automation, and 2.891 Management for Engineers. The effort for manufacturing education is coordinated with the LFM program. Many students in LFM enroll in subjects in the department in the areas of manufacturing processes, automation, systems, and design for manufacturing.

Organization

The graduate program is administered through the Graduate Office under the supervision of Professors Ain Sonin (Chair, Graduate Committee and Registration Officer) and Rohan Abeyaratne (Graduate Admissions Officer). Ms. Leslie Regan is the Graduate Programs Administrator.

STUDENT AWARDS

Many students in the department were recognized for academic excellence, engineering creativity, and community service.

Carl G. Sontheimer Prizes were awarded to Adrian M.T. West.

The Department Service Award was awarded to Craig B. Zilles.

The Reinhold Rudenberg Memorial Prize was awarded to Alexander E. Long and Goro Tamai.

Robert L. Hallock Awards were presented to Daniel Wolfenzon and Jean-Fei J. Cherng.

Whitelaw Prizes were awarded to Carlos A. Herrera and Michael K. Fang.

Luis de Florez Awards were presented to J. Gregory McCandless and Cary Gumbert.

The Wunsch Foundation Silent Hoist and Crane Awards were presented to Gloria M. Ro, Mark M. Hytros, John T. Van Houten, Matthew Manning, Chad P. Findley, James E. Gouldstone, Jeffrey A. Gourde, and Nayana V. Ghantiwala.

RESEARCH

Activity Areas and Support Levels

Research in the department varies from very basic, fundamental work to the conception, design, and prototype evaluation of innovative systems to serve the needs of society. The majority of the faculty are explicitly involved in basic research, and almost every research project in the department has a fundamental component. The department is also quite involved in interdisciplinary research. Collaborative effort in engineering systems is an important component of the department's commitment to research, since it facilitates the exchange of ideas and fosters collaboration across the traditional disciplinary boundaries of engineering. Much of the department's interdisciplinary work is done through established laboratories and centers at MIT. These centers include the Energy Laboratory, the Laboratory for Manufacturing and Productivity, the Materials Processing Center, the Health Sciences and Technology Program, the Leaders for Manufacturing Program, and the Center for Transportation Studies.
The Manufacturing Institute was created, with initial funding from the National Science Foundation, to bridge the gap between academic research and the needs of industry. Drawing upon MIT's vast research base and working closely with industry and government agencies, the Manufacturing Institute goes beyond the scope of traditional academic research laboratories to develop and deploy actual working technologies all the way to the factory floor. With the mission of accelerating the process of scaling up basic research into working technologies for industry while educating engineering students, it serves MIT as a "teaching factory." During the past year, it has completed two technology studies for industry: one on advanced syringe manufacturing, the other on the manufacture of optical devices. Currently under way are projects on the follow-up phase of the optical device manufacture and on innovative housing construction technologies. The Institute has also teamed up with defense contractors in responding to government Requests for Proposals that stress both high performance and low cost.

The department's Center for Information-Driven Mechanical Systems, the mission of which is to create new paradigms for interdisciplinary studies, has grown in the last several years, especially in the area of intelligent machines. Further strengthening of the Center has occurred with the formation of the systems research group in the general field of information technology.

The volume of sponsored research for the 1992-1993 year administered through the department is $8.5 million, approximately a nine percent increase from the volume last year. Additional sponsored research of an approximately equal amount is administered through interdepartmental laboratories and centers in which department faculty participate. The department continues to receive strong research support from industry and private foundations, which now accounts for approximately 46 percent of the total departmental research volume. This is a significant achievement of the faculty, especially in view of the increasingly competitive environment for research funding.

Research By Disciplinary Division

**Mechanics and Materials**

Acoustics: random vibration; rotor dynamics; wideband structural response; machine diagnostics; nonlinear wave propagation and stability; fluid-structure interaction. Computational methodologies: fundamental numerical techniques; nonlinear and fracture analyses. Manufacturing: laser machining; robotics; three-dimensional printing; magnetic levitation; precision engineering; liquid droplet manufacturing; microcellular plastics; scheduling; composites processing and fabrication; friction and wear; Axiomatic design. Mechanics and Materials: theoretical and experimental analyses of metals, polymers, oil, shale, synthetic skin, fibers, and composites; forming, fracture, fatigue, creep, nondestructive evaluations of the above materials.

**Thermal and Fluid Sciences**

Automotive and Combustion: spark ignition engine operation; engine lubrication; fuel composition to reduce emissions and enhance performance; analytical and diagnostic methods in automobile product development; computational methods for mixing and reactions in complex flows; new engine (e.g. two-stroke cycles) and vehicle technology to improve fuel consumption, noise and emissions; policy strategies for improving urban transportation. Cryogenics and Thermodynamics: development of a superconducting generator; fundamental heat transfer mechanisms during oscillatory fluid flow in Stirling engines; design and development of cryocoolers based on principles such as isothermal expansion and adiabatic demagnetization; heat transfer in microstructures and novel materials such as high-Tc superconductors, diamond, and compound semiconductors; applications to the design of VLSI integrated circuits; design and development of a novel infrared radiation detector combining silicon micromachining with superconducting film technology, and of precision temperature control techniques for thin-film deposition processes. Fluid Mechanics, biomedical: arterial flows and atherosclerosis; pulmonary flows and respiratory disease; flows in the eye with application to glaucoma. Environmental: electroosmotic decontamination of waste sites; prevention of fouling in membrane water treatment processes. Computational: numerical simulation of complex flows with parallel processing; hypermedia; computational procedures in design; new image enhancement algorithms. Manufacturing and Instrumentation: buildup of physical objects and materials by precise high-frequency deposition of molten microdrops (e.g. 3D xerography). Physico-chemical: rheology of
dense slurries; properties of macromolecular solutions, with applications in biomedical processes; cavitation; ocean sedimentation dynamics. Heat and Mass Transfer: design and performance of two-phase flows in steam generators, boilers and condensers; turbulent transition for energy-efficient heat transfer augmentation; two-phase problems in nuclear reactors, thermohydraulic design of containment and safety systems for passively-safe nuclear power systems; design of safe nuclear fuel transportation systems; jet impingement cooling for extreme power density heat removal; aerosol transport, with application to pollution control, cleanroom design and transport in the lung; fluidized bed systems for clean coal combustors; heat and mass transfer in porous thermal insulation for energy-efficient building design.

**Design and Control**

Control Theory and Implementation. Nonlinear and adaptive control systems: digital and microprocessor-based control systems; time delay control systems; control-relevant physical systems modeling. Bioengineering and Living Systems: biomechanics and neural control of movement; microsurgery systems; man-machine systems and human factors; medical image processing; haptics and virtual environment systems. Robotics: tele robotics; robot control on mobile platforms; robot impedance control; information-driven mechanical systems. Mechanical Systems and Manufacturing: precision mechanical systems control; integrated electromechanical systems (Mechatronics); control of manufacturing processes; automated manufacturing; vehicle dynamics. Computer-Aided Design and Manufacturing: networked computer-aided design, workshop metaphor; computational tools for design of free-form surfaces, mechanical assemblies and tolerances; automated aesthetic design, automated assembly; three-dimensional printing: rapid tooling and prototyping; Engineering Design Instructional Computer System. Design and Design Methods: design methodology; computational tools for design engineers; precision engineering; Axiomatic design; braced manipulators. Biomedical: advanced medical devices; musculoskeletal modeling; biomechanics of head protection.

**Research By Engineering Systems Group**

**Manufacturing**

New microconstructive additive processes such as 3-D printing of ceramics and metal droplet printing; new forming technologies such as programmable dies for sheet metal forming and elastic diaphragm forming of advanced composites; new control technologies for machines and machine tools including precision magnetic bearings and kinematic fixtures; projects in new materials, design, design methodologies, and manufactured systems modeling; microcellular plastics processing; tribology of undulated surfaces; tribology of hip joints; droplet-based manufacturing; precision engineering; low cost manufacturing of optical devices.

**Biomedical Engineering**

Investigation of the cell-matrix interactions responsible for generation of substantial mechanical stresses in healing wounds; the design and synthesis of implants which induce regeneration of peripheral nerve activity; modeling and identification of electrically stimulated muscle; combined voice and motion control of assistive technology; biological control of posture, movement, and contact; haptic perception of "virtual" objects; robotic aid for patient examination and physical therapy; computer-aided surgical simulation of femoral and tibial osteotomy; force- and pressure-sensing endoprosthesis; movement-induced orientation of collagen fibrils in cartilaginous tissues; synovial joint mechanics and the pathogenesis of osteoarthritis; quantification and display of musculoskeletal anatomy; development of artificial muscles; studies of aqueous humor dynamics for understanding the pathogenesis of glaucoma; and the movement of liquid along pulmonary airways due to surface tension gradients in health and for drug administration, numerical design and optimization of cardiac assist devices. New projects: development of standardized methods of generation, network transmission, and analysis of medical images; the Program for Biomedical Engineering; assessment of current programs and curricula in biomedical engineering; and the development of an undergraduate minor in biomedical engineering.
**Information**

Information and control technology for machine design: knowledge-based systems for process control; concurrent control software design and machine hardware design; human factors for systems design and their applications to product design and IVHS, HVAC, and telerobotics; learning and adaptation to unknown environments; teaching of electromechanical systems design; human centered control. Engineering analysis and synthesis using information technology: hypertext and hyper media; intelligent CAD. Devices for information processing: high density data storage using scanning tunnel microscopes. Manufacturing and information-control issues: quality assurance and robust technology; discrete event systems (Petri nets) and their applications to job shop scheduling and simulation; virtual factory, virtual prototyping; design of experiments. Virtual Environment; rapid prototyping and rapid product development.

**DEVELOPMENT FUNDS**

The department benefits significantly from donations and grants given by MIT alumni, friends, foundations, and industrial organizations. These discretionary funds have been used to initiate new research areas, to acquire equipment for teaching and research, to enhance new faculty development, and to endow and upgrade the research and teaching laboratories. In addition, funds are made available to students for fellowships, scholarships, and prizes. Very significant support has been received from many alumni and friends including Mr. and Mrs. Neil Pappalardo, Drs. Roger and Gail McCarthy, Mr. and Mrs. Eric Newman, Mr. and Mrs. Lee Martin, and Professor Emeritus and Mrs. Warren Rohsenow. Major contributions have been received from AMP, Dynatech, Ford, Shell, General Motors, Becton Dickinson, FloDesign, American Cynamid, Digital, Foxboro, and Koyo Seiko. Contributions are being sought for fellowships honoring Professors Emeriti Cook, Crandall, McClintock, Rohsenow, and Shapiro.

**FACULTY AND STAFF**

**Size and Composition**

As of July 1, 1994, there were 58 full-time faculty; 37 professors, 13 associate professors (10 with tenure), and 8 assistant professors. The teaching, research, and technical staff fluctuates around 70, more than half of whom are part-time.

**Organization and Management**

The department is organized in three disciplinary divisions and three systems research groups. The divisions are: Mechanics and Materials (Head, Professor Triantaphyllos Akylas); Thermal and Fluid Sciences (Head, Professor Anthony Patera); and Design and Control (Head, Professor David Gossard). The systems research groups are: manufacturing (Head, Professor Timothy Gutowski); Biomedical Engineering (Head, Professor Roger Kamm); and Information (Head, Professor Haruhiko Asada).

**Accomplishments and Awards**

Professor K. Jürgen Bathe's research group was the recipient of a Rocca Fellowship from CINI.

Professor Stephen Crandall received the American Academy of Mechanics Medal.

Professor C. Forbes Dewey was elected as a Senior Member of the Biomedical Engineering Society.

Professor James Fay recently wrote and published his book *Introduction to Fluid Mechanics*.

Professor Frank Feng was awarded the Doherty Award.

Professor Woodie Flowers was awarded the A. Neil Pappalardo Chair. He was also elected into the National Academy of Engineering. Professor Flowers also received the Mac Vicar Faculty Fellow Award for teaching.
Professor Timothy Gutowski was appointed the Director of the Laboratory for Manufacturing and Productivity.

Professor Ian W. Hunter was recipient of the first d'Arbeloff Scholar Award.

Professor Harri Kytömaa and his former student received the Moody Award, an ASME Fluids Division Award.

Professor John Lienhard recently received the W.M. Keck Foundation Award for Engineering Teaching Excellence.

Professor Anthony Patera was awarded the School of Engineering Spira Teaching Award.

Professor Alexander H. Slocum was awarded the R&D 100 Award for his "Replicated Internal Shear Damper".

Professor Joseph L. Smith, Jr. is holder of the Samuel C. Collins faculty Chair.

Professor Nam P. Suh received an ASME Tribology Division Award.

Professor James H. Williams, Jr. was awarded the Aetna 1994 Calendar of African-American History in Washington, D.C.

Nam P. Suh
The department had a very productive year, with several national and international initiatives undertaken. In October 1993, we hosted the Second MIT International Conference on the Next Generation of Nuclear Power Technology, with more than 80 invited participants representing reactor vendors, utilities, environmentalists, and regulatory agencies. In the spring term the department faculty participated in reviewing the nuclear power technology options for advanced reactors in Korea and the research and development plans of the European Nuclear Center at Petten (Holland). In April of 1994, the department and the Alpha Nu Sigma Honor Society cosponsored the fourth David J. Rose Lecture in Nuclear Technology. Professor Wolf Hafele, Director of the Research Center at Rossendorf/Dresden, Germany, was the invited speaker. The subject of his presentation was Nuclear Energy in a Global Context.

The reanalysis of the accident at the Chernobyl power plant in the Ph.D. thesis of Alexander Sich, supervised by Professor Norman Rasmussen, made headlines all over the world. By reviewing data from the site of the Chernobyl reactor plant in the Ukraine, Dr. Sich concluded that the mitigative effort of pouring concrete over the core during the accident was ineffective in limiting the radioactivity released.

The department concluded a long-range plan that calls for consolidation of its fission and fusion areas into an "energy" area and shifts a higher fraction of its resources to radiation science and technology applications in the environmental, industrial, and biomedical areas. The implementation of this plan has begun by initiating a broad review of the graduate curriculum with the intention of creating a core curriculum for all graduate studies prior to specialization. The undergraduate curriculum is already organized into two tracks: "energy" and "radiation for medicine and industry."

New research facilities added this year include a spatial NMR laboratory by Professor David Cory (located at the Magnet Laboratory), an accelerator laboratory by Professor Jacquelyn Yanch and Dr. Richard Lanza, and a fusion materials testing laboratory by Professor Ronald Ballinger (located at the Plasma Fusion Center).

The department continues to expand its professional education activities. A new one-week course on management issues of nuclear power plants was launched in June. The Reactor Technology Summer Program for Utility Executives, offered for the first time last summer, is again being offered in the summer of 1994. This five-week course, cosponsored by the National Academy for Nuclear Training, is designed for utility executives, and provides information on basic reactor technology as well as safety considerations that are important for knowledgeable management. Another summer professional program, Nuclear Power Reactor Safety, an annual event since 1966, continues to be a very popular two-week course, attracting over 50 students each week.

UNDERGRADUATE PROGRAM
The undergraduate enrollment near the end of the spring term 1994 was 32 (11 sophomores, 15 juniors, and 6 seniors). Seven undergraduate degrees were awarded during the year (5 S.B. and 2 S.B./S.M.). Of the seven degrees, three went to women.

A minor program in Nuclear Engineering was adopted by the department and was approved by cognizant MIT committees. An undergraduate student may satisfy the requirements of the minor by completing seven subjects related to nuclear engineering.

The undergraduate major in Nuclear Engineering was also modified by incorporating two chemistry subjects (Organic Chemistry and Chemical Thermodynamics) as options for students in the track "Radiation for Medicine and Industry." These subjects fit well into the existing program for students interested in a career in the environmental and medical fields.

GRADUATE PROGRAM
Twenty-nine new students entered the graduate program during the fall semester. Of the 146 graduate students registered, 44 percent were engaged in fission studies, 31 percent in radiation applications in biomedical and other technology, and 25 percent in fusion.
FACULTY HONORS, AWARDS, AND ACTIVITIES

Professor Elias Gyftopoulos received the 1993-94 Ruth and Joel Spira Award for Teaching Excellence.

The American Nuclear Society (ANS) MIT Student Chapter Outstanding Teaching Award was awarded to Professor Rasmussen. He was the chair of a committee formed by the National Research Council to conduct a three-year study of actinide transmutation and its impact on high-level nuclear waste management.

Professor Neil Todreas was invited to serve as vice chairman of the Institute of Nuclear Power Operations' Advisory Council, with plans to succeed as chairman next February. He is also serving on the International Scientific Advisory Committee for SCK (Belgium).

Professor Michael Golay organized and chaired the Second MIT International Conference on the Next Generation of Nuclear Power Technology, held in October 1993. He is a member of the Office of Technology Assessment's Advisory Panel on Nuclear Power Reactor Aging, and will be a member of the US Nuclear Regulatory Commission's Nuclear Safety Research Advisory Committee during the coming year.

Professor Ian Hutchinson spent six months on sabbatical at the international JET tokamak research center participating in the restart of their upgraded experiment, and promoting collaborative efforts between JET and Alcator C-Mod.

Professor Kevin Wenzel organized and edited a special issue of the Journal of Fusion Energy (Vol. 12, No. 3, September 1993). This issue focused on the contributions of small experimental programs to fusion energy development.

Professor Richard Lester served on the US Department of Energy committee to review the future of the national laboratories.

Professor Cory organized a session on materials imaging at the Experimental NMR Conference. He also served as vice chairman of the American Society for Testing and Materials section on nuclear magnetic resonance (NMR) standards.

Professor Sow-Hsin Chen was selected as a "Liquid Board" member of the British Journal of Physics: Condensed Matter.

Professor Emeritus Michael Driscoll was elected by the Board of Directors to the rank of Fellow of the ANS.

RESEARCH

Fission

Studies designed to upgrade and relicense the MIT Reactor (MITR) are underway by Professors Otto Harling, Allan Henry, David Lanning, and John Meyer, and Dr. John Bernard. Projects involve licensing the MITR for power levels up to 10 MWth, and the use of the MITR thermal column for a fission "plate" converter to provide epithermal neutrons in medical treatments by boron neutron capture therapy (BNCT). The work has included development of a computer program to treat reactor primary loop transients; a study of secondary components (heat exchangers and cooling towers); the start of an experimental and computational treatment of velocity and temperature patterns in the reactor tank above the core; and the initial development of a new approach for handling of uncertainties in design.

Work is continuing on model based control methods involving applications of digital control. Professor Henry has continued efforts to speed up the computation of the detailed power distribution throughout a reactor during transients. Two alternative methods are now being examined. The first is called one-dimensional synthesis: precomputed, two-dimensional, static power distributions are stitched together using one-dimensional, time-dependent functions. The second is called a super-nodal scheme: the power computed statically for perhaps 5,000 subvolumes of the reactor (called "nodes") is used to correct transient equations involving perhaps only 80 nodes. Another of his projects involves the computation of nodal parameters. Attempts have been made to find these parameters by using the Monte Carlo code MCNP, but the statistical accuracy required is so great that the method is impractical. Multigroup, discrete ordinate procedures, while still long-running, have been shown to provide a
more satisfactory approach. One reason that the code MCNP is inefficient for finding nodal parameters is that it lacks a number of edits needed for that purpose. The code is currently being extended to incorporate such edits.

With support from the Advanced Neutron Source project at Oak Ridge, Professor Henry and his students have been developing methods for analyzing severe accident transients for that very high flux reactor. A nodal method using parameters derived from static, multigroup, discrete ordinate calculations has been constructed and shown to predict results significantly different from those predicted by the point kinetics approximation.

A method (based on point synthesis) for inferring reactivity from in-core detector readings was developed by Professors Lanning and Henry and tested numerically several years ago. They are now testing the method experimentally using the MITR.

Professor Kenneth Russell developed a theory for precipitate nucleation while irradiation destroys some embryos. The theory is highly relevant to accelerated tests of pressure vessel embrittlement.

In the area of nuclear waste policy analysis, Professor Kent Hansen continued development of models of nuclear waste management programs at Hanford site using system dynamics techniques.


Under the supervision of Professors Todreas and Driscoll the following research accomplishments were achieved:

- An innovative large power rating, light water pressure-tube reactor concept was evolved and analyzed which accommodates the loss of primary coolant by passively flooding the low pressure tank housing the reactor core.
- A variety of devices were conceived and tested to switch heat transfer between high to low rates over narrow temperature bands. These thermal switch devices have application in nuclear reactor systems as well as a variety of other thermal control devices.
- A passive containment cooling scheme which places an annulus of water around the outside of the containment was conceived and its performance tested by a proof-of-principle laboratory experiment.

Radiation Science and Technology

X-ray and neutron surface specular reflectivity, which has been growing in importance over the last ten years, is a technique to probe the surface depth profiles of molecular thin films deposited on a silicon substrate, or liquid surfaces at the resolution of 10Å. The technique has been hampered, however, by lack of a model-independent method for inverting the surface profile from the experimental reflectivity data. Professor Chen and his former student, Dr. Xiao-Lin Zhou, have recently overcome this difficulty by developing a numerical scheme and providing a workable computer code to obtain the surface depth profile from the reflectivity data. The method has been tested successfully for several practical samples, including polymer films and complex liquid surfaces. This has been a major accomplishment in applying the reflectivity probe to unknown molecular surfaces. Dr. Zhou, who will join the faculty in the coming year, will further explore this area.

For the first time ever, an actively loaded tensile test was conducted in the MITR with the tensile specimen located in a high pressure and high temperature water environment which closely simulates the primary coolant system of a light water reactor. This system for in-pile testing has been developed at the MIT Nuclear Reactor Laboratory under the guidance of Professors Ballinger and Harling, and Dr. Gordon Kohse.

Professor Harling and his graduate students have completed the neutronic design for a new high intensity epithermal neutron beam which will enable BNCT to be completed in ~100 sec. This design would enable the MIR-II to be used for routine BNCT on several thousand patients per year.

Under the direction of Professor Cory, the Spatial NMR Laboratory continues to grow. A 400 MHz NMR spectrometer has been added, and he is presently building a NQR spectrometer for exploring microdosimetry. The Spatial NMR Laboratory continues as a state-of-the-art facility for exploring a wide variety of magnetic resonance methods, including solid state imaging, NMR microscopy, NMR diffusive scattering, and RF gradient spectroscopy.

- Professor Cory and his students have built an NMR microscope and are working to demonstrate high resolution NMR imaging. The goal is to achieve 1 µm³ voxel sizes — approximately an increase of 1,000 in volume resolution.
over previous studies. This advance is achieved by designing the system to avoid signal attenuation due to molecular diffusion and due to the gradient bandwidth limitation.

- A diffusive scattering spectrometer has been designed and constructed. The probe employs quadrupolar gradient coils capable of generating in excess of 1,000 G/cm at 30 A. This permits the exploration of q-space through approximately \((0.01 \, \mu m)^{-1}\). Professor Cory and his students are calibrating the system and exploring the theory of two-dimensional q-space correlation experiments. In a related set of experiments, they are exploring the possibility of using atomic force detection to record magnetic resonance diffusion experiments at q-spacings of \((2.5 \, \AA)^{-1}\). This would clearly bridge the gap between NMR and Neutron Diffraction q-space measurements.

- Professor Cory and his students have performed a series of flow measurements with a special purpose NMR transducer that converts translational spin motion directly into a frequency offset of the NMR spectrum. An NMR coil that creates a spatially modulated RF field is used for this flow measurement. Two examples have been explored: an amplitude modulated field appropriate for linear flow systems, and a phase modulated field appropriate for fluid confined in an annular region. Both show all elements of the calculated response.

- Professor Cory and his students have calculated the criteria for constant-time imaging of solids, and they have clearly stated where phase only encoding is superior to more conventional spin warp imaging.

Professor Emeritus Gordon Brownell was engaged in the continued development of PCR-II, a high resolution positron tomograph; design of a microtomograph for animal PET imaging; and the development of programs for image reconstruction.

Using neutron radiography and tomography to produce three-dimensional images, Dr. Richard Lanza has developed a new technique for detection of component failure and of corrosion in structures. The system uses a new compact, portable accelerator based neutron source combined with cooled solid state imagers to produce high resolution images of corrosion. A major application of this technology will be in the aircraft industry and in evaluation of large industrial components such as in power plants and waste remediation facilities.

Fusion

Alcator C-Mod, headed by Professor Hutchinson, has made excellent progress, especially in studies of the divertor, a problem of great interest to the international ITER project. This will be reported in more detail by the Plasma Fusion Center.

Two areas of research were supervised by Professor Mujid Kazimi and Professor Meyer. The first was aimed at developing a first wall, blanket, and shield configuration for a fusion power reactor that would permit passive cooling after a complete loss of coolant flow (without depressurization). The conceptual design of the reactor was completed successfully with a helium coolant, a ferritic steel structure and beryllium conduction paths. The second area dealt with challenges associated with unique heat transfer mechanisms now expected in water cooled fusion divertors. The researchers feel that the conditions necessary for the unique behaviors are as follows: cold coolant, very high heat flux, and high velocity. Under these conditions, water may be able to remove 20 MW/m^2 in heat flux. This is being examined experimentally. Additionally, a probabilistic approach for defining the reliability of the divertor has been proposed.

Professor Jeffrey Freidberg has expanded his theoretical activities into the area of superconducting magnet research, with a particular focus on the problem of quench propagation. He is continuing his research in MHD stability of tokamak plasmas surrounded by resistive walls, a problem of great importance to the TPX experiment. He has given invited talks on these subjects at Columbia University and the Department of Energy's Office of Fusion Energy.

Graduate research assistant Dimitri Pappas and Professor Wenzel have constructed a pair spectrometer with which to study gamma-ray emissions from the D-T and D-\(^3\)He fusion reactions. The spectrometer relies on a magnetic field to separate the orbits of electron/position pairs generated by gamma-ray interactions in a high-Z foil. The ultimate position of these particles when they strike silicon position-sensitive detectors depends on the original gamma-ray energy. In the course of testing the x-ray response of new XUV photodiodes with 100 percent quantum efficiency, Professor Wenzel discovered that the detectors exhibit substantial gain. This signal amplification is realized when the bias voltage applied to the detectors is raised above the level for full depletion. No physical mechanism has yet been identified to account for this gain. Professor Wenzel studied radioactive isotopes present in the Alcator C-Mod RF limiter when it was removed from the machine after its initial operating period. The gamma-ray spectrum so obtained was used to identify the isotopes present and demonstrate that they were due to
photon-induced transmutations. The occurrence of these high-threshold reaction products indicated that runaway electrons with energies above 20 MeV had impacted the Alcator C-Mod limiter.

Systems and Policy

Dr. Marvin Miller organized a research group to study plutonium disposal from surplus nuclear weapons in the United States and Russia. He coauthored a paper on this subject which appeared in the August 1993 issue of Scientific American. He presented papers on the topic "Reducing the Risk of Nuclear Weapons in the Middle East" at international conferences in Barcelona, Spain; Stockholm, Sweden; and Lisbon, Portugal.

STUDENT AWARDS AND ACTIVITIES
The MIT student branch of the ANS had an especially active and rewarding year as host of the 1994 Eastern Regional Student Conference. The conference, held March 24-27, drew about 80 students from as far as New Mexico and California. The total budget was over $20,000, mainly from industry support, and nearly $2,000 in prizes were awarded. Judging was performed by professors and nuclear industry professionals. The Opening Plenary Session was delivered by James Acord, an artist who works with nuclear-related materials and recently received the 1994 ANS Communications Award.

The Roy Axford award for academic achievement by a senior in nuclear engineering was given to Tamara Galen. The Irving Kaplan award for academic achievement by a junior in nuclear engineering was given to Tammy Stoops.

The Manson Benedict Fellowship for 1994-95 was presented to Brett Mattingly. The Theos Thompson Memorial Fellowship for 1994-95 was awarded to James Deakins and David Fink, both incoming graduate students.

Loren Simon received the Sherman Knapp Scholarship, funded by Northeast Utilities, for 1993-94. National Academy for Nuclear Training Fellowships for 1993-94 were presented to Gary Cerefice, Gabriel Dalporto, and William Kiger III.

Sarah Abdelkader received the outstanding service award for 1993-94 for her contributions to the community both inside and outside the department.

Undergraduate students nominated for Alpha Nu Sigma membership include Emanuela Binello, Bridget Hanser, Ruth Lim, Vincent Ponette, Ms. Stoops, Jay VanAntwerp, and Quentin Walker. Graduate students selected for Alpha Nu Sigma membership include Tamer Bahadir, Frank Felder, Joao Justo Filho, Junne Lung Lin, Mr. Mattingly, and James McCarrick.

The Fusion Energy Division of the ANS selected Ali Shajii as the recipient of the 1994 Student Award for Fusion Science and Engineering.

Seungtaek Choi was awarded the 1994 ANS National Undergraduate Scholarship Award for a sophomore entering the field of nuclear science and engineering.

The Pittsburgh Section of the ANS selected Ms. Stoops as the recipient of the recently established Pittsburgh Section Nuclear Science and Engineering Scholarship.

For his paper at the annual Symposium on Space Nuclear Power and Propulsion, Jonathan Witter received the Manuel Lujan, Jr., Award of the University of New Mexico’s Institute for Space Nuclear Power Studies.

Antonia (Toni) Korzan won the award of First Prize in the Master’s Category for her paper at the Nineteenth Annual Student Conference of the Canadian Nuclear Association and Canadian Nuclear Society, March 1994.

MUJID S. KAZIMI
INTRODUCTION

After the excitement last year of celebrating its centennial, the Department of Ocean Engineering this year had a less historic year. But this was only relative, for several noteworthy events have occurred:

- A completely new undergraduate curriculum was put in place this year.
- An undergraduate minor in ocean engineering was first offered this year.
- A new graduate degree, Master of Engineering in Ocean Engineering, and a corresponding new Program in Marine Environmental Systems were developed and approved and will be offered in the coming fall.
- After more than 12 years, the Department Head decided it was time to return to the good life of a professor, and a search for a replacement has been undertaken.

In addition, the Department’s faculty and staff pursued a variety of outstanding research programs, including some that are receiving wide attention outside of the field of ocean engineering. Three new books were published by faculty members. The Department’s series of biannual workshops, bringing together MIT faculty and students, naval research personnel, naval ship-system designers, and US shipbuilders, has reached maturity, serving fundamental objectives that were hardly envisioned when the first workshop was held eight years ago. These are all described in some detail in the following sections.

UNDERGRADUATE EDUCATION

Undergraduate Offerings: The Department’s newly developed undergraduate program, which was described last year, was inaugurated in the fall term this year. In addition, the new minor in Ocean Engineering was first offered in the fall.

The following subjects, all part of the new curriculum, were taught for the first time this year:

- 13.012 Fluid Mechanics for Ocean Engineers (Professor Dick K.-P. Yue and Dr. David P. Keenan)
- 13.015 Mathematical Methods in Ocean Engineering (Professor Paul D. Sclavounos)
- 13.016 Introduction to Geometric Modeling and Computation (Professor Justin E. Kerwin)

Two more new subjects will appear next year:

- 13.014 Marine Structures and Materials
- 13.017 Design of Ocean Systems I

and one the following year:

- 13.018 Design of Ocean Systems II

In all of the new subjects, the majority of the students enrolled were not majoring in ocean engineering. Thus these subjects, even in their first offerings, are showing some success in attracting students from other programs at MIT.

The students in 13.011 Ocean Science and Technology Laboratory undertook a project in the spring term that received a major write-up in Tech Talk (May 11, 1994, page 5). They developed a "sparker" for deployment on an autonomous underwater vehicle (AUV); it generates sound that can be used for mapping the seafloor and sub-seafloor. This is an adaptation of a standard technique in geophysical exploration (used, for example, to search for subsea oil and gas). In normal practice, however, a high-powered sparker is deployed from a ship, which makes the operation expensive and time-consuming. The use of small devices on AUVs will permit much larger areas to be surveyed at much less cost than with ship-borne systems. The students in 13.011 designed and built their device and then tested it in the water at the MIT Sailing Pavilion. The class was a joint undertaking of Assistant Professor J. Robert Fricke, Dr. Charles Mazel, and Mr. D. Noah Eckhouse, the latter two being members of the Ocean Engineering research staff. More details on the student project can be found in the Tech Talk article.
Undergraduate Teaching in Other Departments: Since undergraduate subjects in the Ocean Engineering Department generally have low enrollments, the OE faculty from time to time volunteer to teach core subjects in other departments, especially when those departments experience teaching overloads. This spring, two senior OE faculty members did just this:

- Professor Arthur B. Baggeroer taught 6.003 Signals and Systems, a core subject in Electrical Engineering and Computer Science and one of the largest classes in all of MIT.
- Professor Jerome H. Milgram taught recitations in 2.20 Fluid Mechanics, a core subject in the mechanical engineering curriculum.

GRADUATE EDUCATION

Master of Engineering in Ocean Engineering: Program in Marine Environmental Systems. This is a new professional degree and a new curriculum that will be offered by the Department starting in September. The program was developed by a faculty committee comprising Professors Alan J. Brown, Judith T. Kildow (chair), Jerome H. Milgram, Henrik Schmidt, J. Kim Vandiver, and Tomasz Wierzbicki. It was approved by the Committee on Graduate School Policy in the winter.

Recognizing rapidly growing needs in the marine field for environmentally trained engineers, the Department created this program to reflect the multidisciplinary nature of ocean-related environmental problems and to develop in students the applied thinking and skills essential for innovation in design and implementation strategies. The program's content and structure pull together the key ingredients of marine systems: management, technology, and science.

Each student will choose a field of concentration composed of a coherent set of four subjects in, for example, monitoring, measurement and instrumentation, management of marine resources, marine safety, acoustic oceanography, or "green" systems (such as ships, ports, offshore structures). Program requirements also include field experience, an interdisciplinary project course, and a thesis. The program is structured to appeal to college graduates who are looking for a fifth year of study for completing a professional degree and to graduate students seeking a second degree. It is expected to require 12 to 18 months, depending on the student's preparation.

Professor Milgram is developing a new subject, *Transport, Fate, and Effects of Ocean Pollution*, to be first offered this fall as the centerpiece of the new program. This subject will provide the background for quantitatively predicting and estimating the distribution of pollution, its by-products, and some of its effects on marine ecosystems. Topics will include equations of motion for ocean flows, ocean currents, molecular and turbulent diffusion, fluid mechanical transport models, seawater properties and chemistry, important chemicals in the ocean, sediment-chemical interactions, chemical-biological interactions, and ocean contaminants and their biological consequences.

An excellent description of the new degree program appeared in *Tech Talk*, May 11, 1994, from which the above report is adapted. Official program requirements will be found in the 1994-95 edition of *The MIT Bulletin*.

Doctoral Examinations. Last year we reported that a record number (22) of students had taken the Department's Part I doctoral qualifying examination in January 1993. This was about 50% above previous records, which we attributed at least partly to the fact that we have moved from twice a year to once a year for this examination. This year the number was almost as high (20), suggesting that perhaps this will be a steady-state level in the near future.

BOOKS


RESEARCH

Autonomous Underwater Vehicles (AUVs) in the Arctic Ocean. The Ocean Engineering Department has been a major participant in Arctic studies since the late 1970s. It has also been a key supporter of the MIT Sea Grant College Program, which is a leader in the development of capable, inexpensive AUVs for exploration and monitoring in the ocean. Now these two programs have come together in a study of Arctic ice.

Although the original purpose of our Arctic effort was to help the US Navy understand sound propagation in the Arctic Ocean (which was then a frontline in the Cold War), the focus of our research has largely changed to more peaceful – and equally important – concerns. The nature of the Arctic ice cap and its behavior strongly influence weather and climate in the Northern Hemisphere. For example, when a break opens in the ice, the temperature at the lower boundary of the atmosphere can suddenly rise from, say, –50°C (the temperature of the ice) to almost 0°C (the temperature of unfrozen seawater). This has a dramatic effect on heat and water transfer at the interface. But we do not understand well what causes the ice to break; we cannot predict where or when it will break. Even when the ice is not breaking, its morphology, composition, and properties are largely unknown.

To obtain better knowledge of ice-cracking and ice-breaking phenomena, the Office of Naval Research has sponsored the Sea Ice Mechanics Initiative (SIMI) to monitor ice failure during actual major cracking events. This has involved deploying coarse arrays of hydrophones to detect when ice cracking begins and then rapidly deploying finer arrays in the neighborhood of a detected cracking event. Professor Henrik Schmidt has been the Chief Scientist for this program. Some preliminary tests were conducted in the Arctic in the fall in preparation for a major test this spring. In the latter, the importance of the project was dramatically underscored when the ice split open right through the middle of the scientists’ camp on the ice, necessitating a hurried, unplanned evacuation of the camp.

Sea ice is a complex material. Not only does its temperature vary dramatically from top to bottom, but its composition is highly variable, depending, for example, on the age of the ice and even on its history. It has been practically impossible to get at the underside of the ice to study its morphology, composition, and properties; this is one of the most hazardous environments in the world for man and even for machines. Thus it was an ideal – and challenging – situation in which to use an AUV. Odyssey II, the newest AUV from the MIT Sea Grant Underwater Vehicles Laboratory (managed by Dr. James G. Bellingham), was fitted out for this mission, and, in March, it was taken to the Arctic for a series of rigorous tests of its capabilities for under-ice mapping, measurement of conductivity, temperature, and depth, and navigation under the ice. It was completely successful in all of these.

The vehicle, with its standard equipment, costs less than $75,000, a small fraction of the cost of other AUVs with similar capabilities. This is the beginning of a new era in autonomous ocean sampling, which will soon make it feasible to collect oceanographic data cheaply, quickly, and in places that were heretofore inaccessible. Communication and navigation systems are being developed so that multiple vehicles can be used in an integrated operation to cover a large area rapidly. Some of the new systems will be tested in an expedition to the Juan de Fuca Ridge (west of the State of Washington) later in 1994.

Open-Ocean Towing. Professor Jerome H. Milgram has returned to the subject of open-ocean towing, on which he wrote the definitive paper in 1988. (At that time, he was also responsible for revising major sections of the US Navy’s Towing Manual.) There are two reasons for renewed interest now, (a) many nuclear submarines are being decommissioned and have to be towed to their ultimate resting places, and (b) second-order very-low-frequency forces can materially influence extreme tensions in heavy seas. It may also be noted that the Navy requires automatic towing machines to be available on tugs that tow nuclear submarines, and at the same time the Navy is retiring many of its tugs with such equipment. Current emphasis is placed on the use of stretchers, which act as soft springs, absorbing the peak loads and ameliorating extreme tensions in the towline. Last summer, tests were carried out at sea to validate the new computer models for towing. As if to underscore the need for new knowledge and technology in this area, a line being used for towing a decommissioned (unmanned) submarine broke in those tests, and a USN nuclear asset remained adrift in the North Pacific for many hours.

Fish Hydrodynamics: Several years ago, Professor Michael S. Triantafyllou proposed that fish and cetaceans may be able to achieve their extraordinary efficiency in swimming by recovering energy from the vorticity shed by their bodies. The basic idea seemed to be validated by flow-visualization pictures available in the open literature, but quantitative confirmation was not possible. Now he is conducting both analytical and experimental studies to try to confirm this
concept. The most ambitious part of this project is the construction and testing of Robotuna, a mechanical model of a tuna. It has a multi-segment, articulated body with sensors and controllers that enable it to replicate the motion of a tuna while various internal measurements are made. The first tests in the Ocean Engineering Test Facility will be conducted this summer.

The story continues to attract wide attention. The Chief of Naval Research visited Professor Triantafyllou’s laboratory to receive a briefing, and many members of the MIT Corporation also attended a demonstration. An article appeared in Scientific American (January 1994); American Public Radio aired an interview; CNN produced a television special on tunas, with much footage from the laboratory. Even the science fiction TV program SeaQuest has used some ideas from this work.

DEPARTMENT ADMINISTRATION

Having served longer than any other current MIT academic department head, Professor T. Francis Ogilvie resigned his position as head of the Ocean Engineering Department, to be effective at the end of August. In April, Dean Joel Moses appointed a search committee, comprising Professors Arthur B. Baggeroer (chair), Henry S. Marcus, Koichi Masubuchi, J. Nicholas Newman, and Michael S. Triantafyllou. Dean Moses plans to announce the appointment of a new department head soon. Professor Ogilvie will continue as a member of the faculty.

FACULTY AND RESEARCH STAFF

Captain Alan J. Brown, USN, was appointed to a three-year term as Professor of Naval Architecture, effective the beginning of the year.

Professor A. Douglas Carmichael is serving as Regional Vice President of the Society of Naval Architects and Marine Engineers, an elected position.

Professor Chryssostomos Chryssostomidis served as Acting Department Head January 1 - June 30, while Professor Ogilvie was on sabbatical leave. In December, he completed his third and final year as Professor of Teaching Innovation in the School of Engineering. Professor Chryssostomidis has just started a term on the Marine Board of the National Research Council.

Professor Leo Felsen's appointment as Visiting Professor expired at the end of the academic year.

Professor Francisco Fernandez-Gonzalez of the Universidad Politecnica de Madrid has been a visiting professor since the beginning of the academic year. His stay at MIT will continue through the coming summer. He has been collaborating in research with Professors Alan J. Brown, Chryssostomos Chryssostomidis, and Tomasz Wierzbicki.

Professor Ernst G. Frankel became Professor of Management in the Sloan School of Management at the beginning of the year. He continues also as Professor of Ocean Systems in the Department of Ocean Engineering. Professor Frankel will retire at the end of the 1994-95 academic year, but, as Professor Emeritus, he plans to remain active after that in both teaching and research.

Assistant Professor J. Robert Fricke has been appointed to a three-year term as holder of the Atlantic Richfield Career Development Professorship in Energy Studies, to be effective July 1, 1994.

Dr. Tadashi Hijikata of the Shinsho Corporation in Japan joined the Department in September for a one-year appointment as Visiting Research Engineer. He is collaborating with Professor Koichi Masubuchi.

Professor Henry S. Marcus just completed a term on the Marine Board of the National Research Council.

Professor Koichi Masubuchi has been reappointed as Kawasaki Professor of Engineering for a two-year period.

Professor T. Francis Ogilvie was on sabbatical leave January 1 - June 30, 1994.
LCDR Jeffrey S. Reed, USN, was appointed to a three-year term as Associate Professor of Ocean Engineering, effective at the beginning of the year.

Associate Professor Henrik Schmidt was promoted to Professor of Ocean Engineering, to be effective July 1, 1994.

Professor Wu-Ting Tsai of the National Taiwan Ocean University has just joined the Department for a three-month appointment as Visiting Professor. He is collaborating with Professor Dick K.-P. Yue.

Mr. Akira Umekuni of Takenaka Research & Development Institute in Japan joined the Department in July for a one-year appointment as Visiting Research Engineer. He is collaborating with Professor Koichi Masubuchi.

Associate Professor Dick K.-P. Yue was promoted to Professor of Ocean Engineering, to be effective July 1, 1994.

Dr. Rong Zhao of the Norwegian Technical University in Trondheim ended his one-year appointment as Visiting Research Engineer in August. He collaborated with Professor Michael S. Triantafyllou.

ROBERT BRUCE WALLACE LECTURE

The annual Robert Bruce Wallace Lecture was presented on November 10, 1993 by Dr. Robert D. Ballard, Senior Scientist and Director of the Center for Marine Exploration at the Woods Hole Oceanographic Institution. His topic was *The Development of Telepresence at Woods Hole and its Use in Scientific Research and Education.*

MARTIN A. ABKOWITZ INTERNATIONAL FELLOWSHIP PROGRAM

Family and friends of the late Professor Martin A. Abkowitz have established an endowed fellowship to support travel by MIT graduate students, research staff members, and faculty to international symposia and to foster cooperation among nations in ocean engineering. Special priority will be given to younger members of the community.

ALUMNI EVENTS

In September, the Department held its annual alumni reunion in New York in conjunction with the Annual Meeting of the Society of Naval Architects and Marine Engineers. Assistant Professor J. Robert Fricke was the featured after-dinner speaker.

Professor Ogilvie gave talks to six MIT alumni clubs around the country during the winter and early spring, describing to them the MIT vision of the future of ocean engineering. He spoke to clubs in Orlando, West Palm Beach, Phoenix, Tucson, San Diego, and San Francisco. In Tucson, the local alumni club was joined in a mini-reunion of the Class of 1932.

FIFTH MIT/NAVY/INDUSTRY COOPERATIVE R&D WORKSHOP

The first of these workshops was held in 1986 to help expose the officer-students in Course XIII-A to the communities with which they will have to interact after graduation. From the beginning, we brought in the naval ship-design community (primarily the Naval Sea Systems Command), US Navy laboratories and the Office of Naval Research, and several major builders of ships for the US Navy. It immediately became apparent that the workshop filled another purpose, namely, providing a forum in which these disparate communities could communicate with each other. At each successive workshop, the format has continued to mature, and the number of participants has increased. The workshop this year, which was held 18-19 May 1994, was attended by more than 100 persons. Although no archival record of the proceedings of the workshop is kept, most of the participants consider that it serves a unique purpose, especially under current public demands for better coordination from R&D through design to fabrication.
The program opened with reports by teams of students on their year-long design projects, which this year included (1) a large-capacity missile carrier (LCMC), (2) a fleet-logistics and environmental-support ship (FLES), and (3) a littoral-warfare submarine (LWS). The Workshop had three featured speakers, (a) Mr. Ronald K. Kiss, Deputy Assistant Secretary of the Navy (Ships), (b) Dr. Arthur E. Bisson, Director of Science and Technology, Office of Naval Research, and (c) Dr. David D. Moran, Director of Industrial Outreach, Office of Naval Research. Three panel discussions were held, focusing respectively on R&D issues, likely design trends and requirements, and manufacturing issues. Finally, there were several technical sessions, in which people with particular interests could join specialized break-out groups to hear about current research at MIT and discuss needs for future research. The panel discussions were new this year, and the format of the technical sessions was new too.

T. FRANCIS OGILVIE
The primary goal of the Artificial Intelligence Laboratory is to understand how computers can be made to exhibit intelligence. Two corollary goals are to build intelligent systems and to understand certain aspects of biological intelligence. Current research in the Laboratory includes work on robotics, vision, natural language, enhanced reality, learning, reasoning and problem solving, model-based expert systems, engineering design, supercomputing, and basic theory. Major new applications themes include information transportation, access, and analysis, enhanced reality technology, and applications of artificial intelligence in medicine. Professor Patrick H. Winston works on the problem of learning from precedents. Professor Marvin Minsky develops general theories of intelligence and knowledge representation. Professor Robert C. Berwick studies fundamental issues in natural language, including syntactic and semantic acquisition. Professor David A. McAllester works on knowledge representation and automated reasoning. Professor Lynn Andrea Stein works on integrated architectures for intelligence. Professor W. Eric L. Grimson, Professor Berthold K. P. Horn, and Professor Tomaso A. Poggio do research in computer vision. Professor Rodney A. Brooks, Professor Tomas Lozano-Perez, Professor Marc H. Raibert, Professor Warren P. Seering, and Dr. J. Kenneth Salisbury work on various aspects of Robotics. Professor Randall Davis and Dr. Howard E. Shrobe work on expert systems that use both functional and physical models. Professor Carl E. Hewitt studies distributed problem-solving and parallel computation. Dr. Thomas Knight and Professor William J. Dally work on new computer architectures. Professor Gerald J. Sussman and Professor Harold Abelson lead work aimed, in part, at creating sophisticated problem-solving partners for scientists and engineers studying complex dynamic systems.


VISION

Object Isolation and Identification

Professor Grimson's group has focused primarily on methods for recognizing objects in cluttered, noisy, unstructured environments. Such systems have been incorporated into a hand-eye system, into a navigation system for autonomous vehicles, and into an inspection and process-control system for industrial parts. Recent efforts have focused on formal methods for evaluating alternative recognition methods, on grouping methods for preprocessing the input data into salient sets of features, on the role of visual attention in recognition, and on the development of efficient meth-
ods for indexing into large libraries of objects. These efforts have been integrated into a system that uses a movable eye-head to find objects hidden in a room by focusing attention on interesting points in the room, and then using grouping and recognition methods to identify such objects.

One key new project is directed at using such methods to enhance the performance of brain surgeons by merging ordinary images of a patient with synthetic images produced using Magnetic Resonance Imaging. We call this enhanced reality. These visualization methods have been used in neurosurgery, and as part of a clinical study of Multiple Sclerosis.

**Motion Vision, Low-Level Integration, and Photogrammetry**

Professor Horn and his students work on problems in motion vision. Currently, the extension of existing methods in the time direction is being explored. While one can get good motion information from just two image frames, distances to objects are determined only rather coarsely. Methods from computer graphics are used to predict the shape and position of an object at the next image frame time, based on the estimated shape and position and the estimated motion at the present time. Dramatic improvements in the accuracy of the reconstructed object shape are attained in this fashion, although after about ten frames the errors introduced by the prediction phase begin to balance out the improvements obtained from continuing the solution in time.

Because the problem of dealing with the arbitrary motion (both translation and rotation) of arbitrary surface shapes presently appears intractable, they are exploring a number of special cases, such as the use of fixation. The equations relating image brightness changes and motion simplify when the camera system is servoed to maintain the image of a particular point in the environment stationary in the image plane. Methods have been developed for fixation that do not depend on tracking identifiable features in the environment. This is of importance in unstructured environments, where there may be texture on the surface being viewed, but no obvious features.

Because recovery of information about the world from a single cue such as motion parallax, binocular stereo disparity, or shading in images tends to not be very robust, there is now a great deal of interest in integrating information from multiple cues. The intimate integration of early vision modules will be required for most practical applications of vision systems. Professor Horn's approach to the problem focuses on intimate integration at the lowest level of vision modules. In the simplest case, this means interlacing iterations of different schemes for recovering shape, or more formally, constructing a compound functional that contains penalty terms for mismatching information available from both cues being considered. Preliminary results in integrating motion vision and shape from shading, and in integrating binocular stereo and shape from shading show great promise. The new approach is particularly attractive because it suggests a systematic methodology for this integration, enabling new visual cues to be included easily.

Professor Horn and his students are also looking into the object recognition through the computation of stable "invariants." While the idea of invariants is an old one in the field, it has in the past been applied to two-dimensional patterns, not three-dimensional objects. There has been some work recently elsewhere on invariants for recognition, but none that actually took into account the constraint provided by perspective projection. Ignoring this constraint leads to unstable methods of
little interest in the real world of noisy data. New "invariants" are now being developed that exploit an accurate knowledge of the imaging model. Those require fewer features and lead to stable recognition schemes.

Finally, work on a new special-purpose early-vision analog VLSI chip will be completed soon. This chip determines the "focus of expansion"—that point in the image towards which the camera appears to be moving. It does this without the need to detect and analyze image features. The result can be used to compute time to impact and possibly to recover shape information. The chip is expected to operate at 1000 frames per second. While it has only a 32 x 32 array of sensors and processing elements, it is expected to be able to recover the focus of expansion with sub-pixel resolution. Work is also starting on the next step, a chip that can deal with arbitrary combinations of translational and rotational motions, provided that the scene being viewed is approximately planar. This chip will be an order of magnitude more complex than the previous one and require considerable innovation before the circuitry can be fitted into the available space.

Machine Learning and Networks

Professor Poggio’s research focuses on the problem of learning a multivariate function from sparse data. Professor Poggio’s group has developed a theoretical framework, based on regularization theory, that has roots in the classical theory of function approximation. The research effort at the Artificial Intelligence Lab and at the connected Center for Biological and Computational Learning continues to grow in several directions: theory and mathematical issues, algorithms for learning, use of prior information to augment the example set, exploiting virtual examples, applications, and neuroscience.

In particular, Dr. Federico Girosi, Michael Jones and Professor Poggio have now succeeded in showing that regularization networks encompass a much broader range of approximation schemes, including many of the popular general additive models, some tensor product splines, and some neural networks. The result is significant because it provides a unified theoretical framework for a broad spectrum of neural network architectures and statistical techniques. Dr. Girosi and Professor Anzellotti have shown that several neural network architectures and function approximation techniques are closely related also from the point of view of the curse of dimensionality. Partha Niyogi and Girosi considered these classes of functions and showed how generalization error depends on the number of examples and on the number of parameters.

Several applications have been demonstrated in visual object recognition, computer graphics, very low-bandwidth video conferencing, video e-mail, feature detection, target detection, visual inspection, visual database search, face detection, time series analysis, and pricing models in finance. For instance, David Beymer and Professor Poggio have developed and tested a view-based pose-invariant face recognition system using several views per person and running on the Connection Machine parallel computer on a data base of about 1000 face images. The recognition rate is about 98 percent on a data base of 68 people. They have also obtained encouraging preliminary results with a pose-invariant face recognition system which relies on only one example per person and the generation of virtual examples through transformations learned from face prototypes.
Kay Kah Sung and Professor Poggio are developing a face detection system, capable of localizing faces in cluttered pictures. This is a specific example of a technology that is critical for object recognition, trainable visual inspection systems (for manufacturing and medical applications) and indexing in large databases of images. Professor Poggio, Beymer, Sung, Stephen Lines and Amnon Shashua have developed and tested learning networks for the analysis and synthesis of images that could be used for trainable man-machine interfaces and very efficient computer graphics, respectively. Together the two systems may provide very-low bandwidth video-email and very-low bandwidth video-conferencing (in the order of a few bytes per frame).

On the biological side, on-going physiological experiments with monkeys are providing exciting results that suggest that the mammalian visual system may use view-based recognition strategies similar to what the model of Poggio and coworkers predicts.

The plan for the future includes further development of the mathematical theory and the development of additional applications. Applications to be explored include object recognition, image data base search and object detection, computer graphics, computer interfaces, and financial models. Biologically, work will focus on exploring how the brain may work and in particular how the visual system may recognize objects.

**NATURAL LANGUAGE UNDERSTANDING AND ACQUISITION**

Professor Berwick and his colleagues have finished constructing the next generation of natural language parsers and translators, based on modular, universal linguistic theories. During the past year, a completely modular parser for Japanese was extended to cover a large subset of this language, and the system has now been extended to Dutch, German, Spanish, and Italian. By taking advantage of a parallel “dataflow” system organization, they have demonstrated nearly linear speedup in parsing, a first in this area.

The results of this work were published in an MIT Press book, *Cartesian Computation*, and will appear in summary form this year in a *Scientific American* article. Additionally, in collaboration with researchers from the Department of Linguistics and Philosophy, the universal parser has been extended to handle examples from Arabic and Hindi.

Professor Berwick also led a special research group on developing multilingual tools for building dictionaries for languages as different as Hindi, Bengali, Greek, and Japanese. He has completed a system for automating this otherwise difficult task.

Finally, Professor Berwick and his students have developed a new model for language acquisition based on the theory of dynamical systems. For the first time, this model can measure the actual number of examples needed to learn a particular language. The system can also model how languages change over time.

**ROBOTICS**

Mobile Robots
Professor Brooks and his students have been working on embodied theories of intelligence. Previous work has concentrated on small mobile robots, and that work has been developed further. But, over this past year, Professor Brooks, in cooperation with Professor Stein, has embarked on a new project—to build a humanoid robot with human-like capabilities.

During the past year two students completed work on ways to program groups of multiple mobile robots in an unstructured environment. Dr. Lynne Parker tackled the heterogeneous case and developed an architecture where the robots could cooperate without explicit negotiation. Instead, the robots all broadcast their actions continuously, and other robots, upon hearing this, may change their actions. Dr. Parker showed the system was robust in the face of great communication degradation, and would converge under a wide variety of conditions. She also added a component so that robots could learn the characteristics of other robots and improve their cooperative performance. Dr. Maja Mataric looked at groups of homogeneous robots, and was particularly interested in the case where no explicit communication was possible. The robots sense the presence of other robots like themselves and change their behavior appropriately, just as social insects interact. Dr. Mataric added a shaped learning capability to the robots and showed that it converged faster than other well known algorithms.

Andrew Gavin completed work on new vision algorithms for a Mars rover, and tested his algorithms in a simulated Martian environment. Michael Binnard developed new techniques for fabricating and controlling a pneumatic six-legged robot. He showed that such a robot could plausibly operate on the Martian surface.

Along with Professor Stein and her students, and students of other faculty in the laboratory, Professor Brooks and his students started work on Cog, a robot with humanoid form. The purpose of this project is to learn what constraints on the organization of human intelligence are imposed by having a body. The first year of the project was dedicated to building hardware and software so as to get a useful substrate upon which higher level work can be undertaken.

Planning For Collision-Free, Compliant, and Grasping Motions

Professor Lozano-Perez and his associates work on computational problems in the areas of robot manipulation, computer vision, computer-aided design and computational biology. During the past year, they have made progress on a variety of fronts. They have demonstrated a system that uses off-line motion planning and simulation to enable a robot to use information from on-line visual sensing to choose appropriate task-achieving commands in the face of substantial sensing and modeling error. They have demonstrated a planning system, implemented on the Connection Machine, for selecting grasps for the Salisbury three-fingered robot hand. And together with Professor Grimson, they have begun field-testing a prototype system for the automatic registration of three-dimensional medical images, such as from tomography and magnetic resonance imaging, with three-dimensional range data from a patient in the operating room.

Work is currently underway on developing autonomous robot agents for distributed simulation systems such as SIMNET, on the use of visual sensing for advanced human-computer interfaces, on
combining off-line robot motion planning with on-line force feedback, and on applying geometric algorithms to the three-dimensional packing of amino acid residues in proteins.

Legged Locomotion

Professor Raibert and members of the Leg Laboratory study legged locomotion in robots, animals, and computer animation. During the past year one of Raibert’s students discovered that the somersaulting motion of a human-like object can be stabilized passively with the right kind of springy arms. Two other students have simulated the physics, appearance, and walking behavior of a giant cockroach and a robot-like cockroach.

Robot and Human Arms and Hands

Dr. Salisbury’s group has focused this year on three areas: sensor guided grasping, study of human and robot hands, and the development of haptic interfaces.

Dr. Salisbury’s study of human and robot hands, in collaboration with Dr. Srinivasan at the Research Laboratory for Electronics, has focused on the development of touch perception algorithms to enable robots to deduce contact conditions, including contact, texture, constraint, and motion. The algorithms use simple force-sensing fingertips and force time-history information. Dr. Salisbury’s group is also developing precision force and motion manipulators for dual use in robot palpation experiments and human psychophysical experiments.

Significant progress also has been made in hardware and program development for our new PHANTOM haptic interface. This device exerts precisely controlled force vectors on user’s fingertips or a stylus and is used to present touch (or “haptic”) information to the user. This permits users to mechanically interact with virtual objects, permitting perception of properties including touch, shape, texture and motion. A larger “tool-handle” version of the device has been build and is undergoing testing. These devices are being used in our laboratory and in RLE as components of the Virtual Environment Training Technology program.

REASONING TOOLS FOR ENGINEERS AND SCIENTISTS

Mixed Symbolic and Numerical Computation

The research of the MIT Project for Mathematics and Computation (Project MaC), under the direction of Professors Abelson and Sussman, is working to demonstrate breakthrough applications that exploit new computer representations and reasoning mechanisms that they have developed. These mechanisms enable intelligent systems to autonomously design, monitor, and understand complex physical systems through appropriate mixtures of numerical computing, symbolic computing, and knowledge-based methods. They call this mixed approach intelligent simulation.

Systems incorporating intelligent simulation can automatically prepare numerical experiments from high-level domain descriptions. They automatically select and configure appropriate numerical methods. They actively monitor numerical and physical experiments. They automatically analyze the results of such experiments, using domain knowledge to interpret the numerical results, and
they report these results to their human users in high-level qualitative terms. In favorable cases intelligent simulation programs can automatically configure special-purpose hardware for efficient execution of computationally demanding numerical experiments.

The group has demonstrated the basic capabilities of intelligent simulation systems. They have implemented computer programs that interpret numerical simulations of nonlinear systems, automatically producing summary descriptions similar to those in the published literature.

They have shown that programs can harness techniques from computer vision to "look at" simulation data and isolate regions of interesting behavior, and they have demonstrated this automatic analysis by discovering new results of current interest in theoretical hydrodynamics.

During the past year, Dr. Andrew Berlin developed and demonstrated novel techniques for using active control to wiggle a structural element in such a way that buckling is prevented. He has performed analysis, simulation, and physical experiments to demonstrate his techniques. These techniques promise to lead to intelligent physical structures with unprecedented strength-to-weight ratios.

The buckling of compressively-loaded members is one of the most important factors limiting the overall strength and stability of a structure. Dr. Berlin has constructed a small-scale model railroad-style truss bridge that contains compressive members that actively resist buckling through the use of piezo-electric actuators. He has also constructed a prototype actively controlled column in which the control forces are applied by tendons, as well as a composite steel column that incorporates piezo-ceramic actuators. Active control of buckling allows this composite column to support 5.6 times more load than would otherwise be possible.

Model Based Reasoning Systems

Professor Davis, Dr. Shrobe, and their associates are building knowledge-based systems that use models of structure, function, and causality to perform a wide range of problem solving and reasoning tasks. The systems they have built can reason about how a device works and how it fails in a manner similar to an experienced engineer. This is an important advance in the art of knowledge-based systems construction, because it provides the system with a more fundamental understanding of the device than is possible using traditional approaches.

Where previous work dealt with digital electronic systems, more recent work is focused on understanding how things work in domains that include simple mechanical devices like four-bar linkages and mechanistic explanations of biological phenomena. Examples of understanding include the ability to produce descriptions of device behavior from a description of their structure, the ability to predict behavior under unusual circumstances, and the ability to redesign to fit those new circumstances.

This work is based in part on the belief that the next major innovation in computer-aided design will be the construction of tools that understand (and can be told) how devices work and that can use this knowledge to support intelligent design modification. In order to be successful, such systems must already know a great deal of the basics of its design domain. A mechanical engineer
takes it as given that a human colleague will understand terms such as "Scotch Yoke," "Four Bar linkage," and "Trip Mechanism," and would never employ a human assistant who did not know the meaning of these and hundreds of other basic terms, their common usages, and constraints on their application. Yet engineers endure such ignorance in their design aids daily.

Making automated design tools powerful and easy to use will require constructing a very large knowledge base of engineering "know how." Such a system will contain roughly an order of magnitude more knowledge than existing commercial knowledge based systems and will lead to a new level of flexibility and power.

Professor Davis has also been leading the Intelligent Information Infrastructure project, which is concerned with the next generation of ideas and software to support the National Information Infrastructure. Their basic assumption is that the National Information Infrastructure should have intelligence embedded into it, allowing it to understand the information it is carrying and enabling it to provide the foundation for new ways to gather, organize, and transmit knowledge, as well as new ways to operate organizations to take advantage of new knowledge structures.

The members of the project have built a variety of systems, including the publication/distribution system used by the White House Office of Media affairs, in use routinely since January 20, 1993 to distribute OMA publications nationally and internationally, and an on-line surveying system used to determine the size and character of the audience receiving the documents. They have also developed and used the START system to provide a natural-language based information resource.

They have also worked with Senator Kennedy's office to establish email and World-Wide-Web connectivity between the Senator and his constituents. They drafted the early versions of the Senator's homepage and continue to assist in updating.

Engineering Problem Solving and Design

During the past year, Professor Seering's group has made advances in understanding the dynamic response characteristics of robot arms. The focus of the group's work has been on system identification and on exploring control strategies for improving robot performance. Efforts are ongoing on finding ways of minimizing undesirable vibrations in dynamic systems. In collaboration with NASA the group has been working to improve the response of flexible space structures. An evaluation of the group's ideas will be run on the Space Shuttle on a flight tentatively scheduled for January of 1995.

Professor Seering's students have also been looking for ways to use computers to help mechanical designers to capture design decisions so that information about those decisions can be retrieved efficiently and at the desired level of detail by a designer. This work is being conducted in collaboration with a team of researchers at the General Motors Technical Center and a group of GM design engineers.
HARDWARE AND SOFTWARE ARCHITECTURES

Symbolic Parallel Architectures

The Symbolic Parallel Architecture group, under the direction of Dr. Knight, has been developing a uniform, large scale, parallel symbolic supercomputer called Transit. Unlike most parallel machines, this architecture has been explicitly designed to support a wide range of parallel programming models with excellent performance. The key realization is the critical importance of low latency in the processor-to-processor communications path. This low latency communications is used as a substrate for coherent caches and processor-to-processor message passing. The implementation of Transit is being done in three phases: construction of the routing network, coherent cache implementation, and finally processor design. The routing network is currently under detailed design and simulation. Its construction involves novel three-dimensional packaging and cooling technology, novel VLSI techniques for chip-to-chip communications, and a very simple, high speed routing component. The initial prototype is expected to yield a remote memory access latency of about 300ns and a per-port peak bandwidth of 800 megabaud. The aggregate switch bandwidth approaches a terabaud.

Initial design of a massively parallel SIMD computer for early vision applications has also begun. The architecture maximizes the number of bits transformed each cycle by allocating a very simple processing element to each bit of a data item. Simulation of low-level arithmetic primitives has been completed, and preliminary VLSI layout issues are now being addressed. A system composed of 144 chips is expected to deliver between approximately 100 billion 16-bit arithmetic operations per second.

Concurrent VLSI Architecture

The Concurrent VLSI Architecture Group under the direction of Professor Dally has been developing techniques for applying VLSI technology to solve information processing problems. The group has been developing the J-Machine, a fine-grain concurrent computer that offers supercomputer performance and tests a number of new concepts in interconnection networks, addressing mechanisms, processor architecture, and concurrent software systems. During the past year, the group completed the design of a single node of the J-Machine, known as the Message Driven Processor. The MDP chip was fabricated by our industrial partner, and first samples of the chip worked correctly, at greater than predicted performance. They have built an initial multi-node system, and expect to complete a 1024 node prototype J-Machine by year’s end. They are continuing to develop system software, languages, applications, and high-speed peripherals for the machine. They have written a distributed operating system and compilers for the Concurrent Smalltalk and Concurrent Aggregates programming languages. As one of the machine’s initial applications, they are developing a high performance, reliable transaction processing system.

Message-Passing Semantics

The Message-Passing Semantics group, under the guidance of Professor Hewitt, has been developing the foundations for Open Systems that perform robustly in changing environments. An Open
System is one that is always subject to unanticipated communications from outside and whose operations are subject to indeterminate results. Robustness means the ability to keep commitments in the face of conflict and indeterminacy, which are ubiquitous in Open Systems. Robust computer systems are needed to meet the challenge of Open Systems so as to gain from the advantages of openness while meeting the requirements that are imposed by openness. Open Systems undergo continual change: some change coming from within, through communication among internal parties, some from without through interaction with the environment.

The primitives of ultraconcurrent systems are called ACTORs. These can be organized into systems of ORGs (Organizations of Restricted Generality). The Actor model provides a scientific and technological basis for Open Systems because it supports dynamic reconfigurability, compositionality, and extensibility. The ORG model provides a scientific and technological basis for organizational systems because it supports teamwork, management, liaison, and organizational representation. The group's research focuses on theoretical, architectural and on linguistic aspects of organizational systems composed of humans and telecomputer systems.

**BASIC THEORY**

**Society of Mind**

Professor Minsky has continued to develop the theory of human thinking and learning called the "Society of Mind." This theory explores how phenomena of mind emerge from the interaction of many disparate agencies, each mindless by itself. For example, one aspect of the theory explains the combination of knowledge representations in different realms of thought as the basis for analogy; another aspect is a "re-duplication" account of natural language, in which grammatical forms are seen as emerging directly from expressive requirements rather than from conventions that communications are forced to fit.

Professor Minsky has continued his interest in the limits and potentials of "connectionist learning systems" and their role in distributed cognitive accounts like the Society of Mind. He is actively considering how such systems may be combined and interconnected in a way that avoids the serious scaling problems of unstructured connectionist systems.

**Automated Formal Reasoning**

Professor McAllester has been building and testing automated reasoning systems. These reasoning systems incorporate a variety of new algorithmic techniques that allow effective automated reasoning about topics that are beyond the scope of any previous reasoning system. For example, Professor McAllester's reasoning systems have been able to verify proofs, starting with only the axioms of Zermelo-Fraenkel set theory, of the Stone representation theorem in lattice theory. This theorem involves an ultrafilter construction and is similar in complexity to the Tychonoff theorem that a product of compact topological spaces is compact. The novel algorithmic techniques mainly involve integration of type inference techniques with general-purpose automated reasoning techniques and bottom up logic programming. Recently theoretical work on the relationship between bottom up logic programming and computational complexity has uncovered a new characterization of the
complexity class P and significant computational properties of inference based on natural language syntax.

Commonsense Reasoning

Professor Stein's group works on issues ranging from cognitive robotics to intelligent software systems. During the past year, the group designed and implemented SodaBot, a software agent environment and construction system. SodaBot transforms high-level descriptions of software agent functionality into efficient platform-specific code which manages interactions with lower level system-specific details such as mailers and socket interfaces. Several software agents have been implemented in SodaBot with order-of-magnitude decreases in code size. Over the next year, SodaBot will be made available to sites across the Internet.

Professor Stein's group also built a system for natural communication with robots. T.J., a sonar-based mobile robot on loan from I.B.M. Watson, was augmented with a system that allows real-time typed natural language communication between T.J. and a human guide as the two wander around an office environment. The human guide can describe locations (which may not be directly perceivable by T.J.) and issue instructions relative to these locations. The augmented T.J. can also answer questions with respect to these locations and autonomously navigate among them. Using this kind of system, a robot can be oriented in a new environment by a novice user.

Finally, Professor Stein's group extended work on adaptable synthetic robot languages. In previous work, robots learned simple proto-languages using a variant on traditional reinforcement learning. In the past year, this work was extended to cover context-dependent and compositional languages, providing significant qualitative and quantitative improvements over the earlier work.

Learning from Analogous Precedents

Professor Winston's group has concentrated recently on developing representations that enable learning and reasoning by analogy. One important component of this research concerns the representation of change in a qualitative manner, such that a remembered sequence of changes can be used as a precedent for understanding how some subsequent situation is evolving. This work, led by Dr. Gary Borchardt, is grounded in the key insight that there is much to be gained by viewing the world from a transition-centered perspective, rather than a state-centered perspective. In principle, a world's state embodies enough knowledge of the world to determine its future evolution, but this state-centered perspective has led to all sorts of practical obstacles (including the "frame" problem and the "context" problem). In contrast, from the transition-centered perspective, transitions cause transitions. Accordingly, the transition space representation focuses on what is changing rather than on the static properties of things.

During the past year, a new program called IMPACT has been completed in prototype form. IMPACT uses the transition space representation to perform "what-if" reasoning about actions considered in complex circumstances. In a sample knowledge base, IMPACT identifies possible consequences of changes in manufacturing operations for a hypothetical electronics company.
Also during this past year, new work has commenced on the development of "associate systems"—programs that help humans gather information about urgent situations, identify and evaluate possible courses of action, and see selected courses of action through to completion. This work integrates "what-if" reasoning technology demonstrated in the IMPACT program with information access technology demonstrated in the START program developed by Dr. Boris Katz.

PATRICK HENRY WINSTON
INTRODUCTION
The Biotechnology Process Engineering Center (BPEC), an interdisciplinary center at the Massachusetts Institute of Technology, is a pioneering program in education and research for the biotechnology industry. BPEC, established in May 1985, is funded by the National Science Foundation (NSF) under the Engineering Research Center Initiative. NSF has approved further funding for BPEC through January 1996 and has the possibility for further funding through 1999.

As an interdisciplinary center, the BPEC reports to the Dean of Engineering, Professor Joel Moses. The Director of the center is Daniel I.C. Wang, Professor of Chemical Engineering. Three associate directors help in the operations of the center. The associate directors are: Charles L. Cooney, Professor of Chemical Engineering and Associate Director for Industry; Gregory N. Stephanopoulos, Professor of Chemical Engineering and Associate Director for Research; and Anthony J. Sinskey, Professor of Biology and Associate Director for Education.

The mission of the BPEC is to develop advanced manufacturing ideas and technologies, to ensure U.S. competitiveness in the production of therapeutic proteins by creating a new breed of professionals. To achieve this goal, the center focuses its efforts through education, research, and industrial involvement.

RESEARCH STRUCTURE
A cross-disciplinary team consisting of biologists, chemists, and chemical engineers executes the research in two thrust areas: 1. Engineering and Scientific Principles in Therapeutic Protein Production; and 2. Process Engineering and Science in Therapeutic Protein Interactions and Stability. Cross-disciplinary educational and research collaborations are especially important components within the center's activities.

A team of 13 faculty members participated in the center's activities from July 1, 1994 through January 31, 1994. With the start of the 10th year funding to the center on February 1, 1994, the center's revised strategic plan caused a reduction in the faculty team to 11 participants. They are from the Departments of Chemical Engineering (School of Engineering), Biology, and Chemistry (School of Science), the Department of Chemistry, Iowa State University, and the Department of Chemistry at Purdue University. Undergraduate and graduate students, postdoctoral fellows, visiting scientists, and industrial associates are integral participants in the center's activities.

Statistically reporting, 164 personnel took part in the center's research activities during fiscal 1994. This figure is comprised of 39 MIT Undergraduate Research Opportunities Program students (UROP); 12 non-MIT undergraduates from 10 different Universities who participated in the center's NSF Research Education for Undergraduates Program (REU); 54 graduate students from four departments; six technical assistants, 11 postdoctoral associates/fellows; 33 visiting scientists, engineers, industry researchers, three other administrative personnel and 11 faculty.

The major financial support for BPEC personnel is provided by the NSF. Additional support for graduate educational activities for the MIT students is provided by the National Institutes of Health (NIH-NIGMS). In addition, unrestricted funds have been secured from outside sources. Industrial donations were received as contracts, fellowships, equipment, and software.

AFFIRMATIVE ACTION
The BPEC is committed to increasing the number of women and minorities in its programs. Our success is dependent on type of applicants. To assure many applicants for the National Institutes of Health Interdepartmental Training Grant, we have formed a minority recruitment committee.

EDUCATIONAL ACTIVITIES
The vision and goals of BPEC's educational programs are to ensure the training contains breadth, depth and balance addressing biotechnology and bioprocess engineering. Some specific goals include an integrated view of biotechnology processing; an atmosphere of team work with cross-disciplinary interactions; an exposure to the real world of industrial biotechnology; and the creation of a new breed of professionals for university, industry and government. Five new courses were introduced by the BPEC faculty in fiscal 1994. Each teaching assistant's
stipend was supported by the center's funds. Outreach activities by the BPEC included the participation of two students from the Wellesley Education Cooperative Program for High School Students in the center's research and visits by 30 under-represented minority students from the City of Cambridge, MA. In addition, workshops where the center's students and faculty can interact on-campus and at other universities and industrial sites were given by the BPEC. The center continued to hold two very active undergraduate programs during Fiscal 1994. The programs are the Undergraduate Research Opportunities Program (UROP) and the Research Experience for Undergraduates (REU). The REU program is funded separately by the NSF program, and as mentioned above, supported 12 non-MIT students. We continued our seminar program entitled, "UROP and REU Seminar," in which the undergraduates presented their research experiences to the center's personnel weekly. The students were provided with basic research and presentation tools as part of the educational program. In addition, BPEC instilled cross-disciplinary and team research in each student.

The outreach efforts in the BPEC have continued during the current 9th year. To reach the pre-college students, the BPEC Technical Coordination Office hosted 30 high school students and four high school teachers to stimulate and to demonstrate the excitement in bioprocess engineering. In addition, Professor Wang along with six BPEC graduate students participated in a one-week course for "High School Science Teachers" where lecture and laboratory tours and demonstrations were part of this activity. The last effort in the BPEC outreach achievement involved the participation of faculty, students and post-doctorals from other universities at this ERC site. Professor Fred Regnier, along with three graduate students from Purdue University, and Professor Cheng S. Lee along with one post-doc and two undergraduates from the University of Maryland, Baltimore County, participated in the Center's research programs during the summer of 1993. BPEC students and research personnel were able to share with these visitors their perspectives and research methods in bioprocess engineering.

At the graduate level, we have continued to bring interdisciplinary ideas into the course teachings. We successfully completed our fifth year on the NIH Interdepartmental Biotechnology Training Program (BTP) which was officially inaugurated in 1989. Funding for this program is provided by the NIH-NIGMS. This program is organized to train 21 Ph.D. students to become providers for the scientific and engineering talent and leadership needed to maintain the growth phase of the new industry, and to educate the next generation. Twenty-five faculty members from MIT are involved, representing the Departments of Biology, Chemistry and Chemical Engineering. Professor Daniel I. C. Wang, the center's director, is also the director of this program. Professor Jonathan A. King, a professor in the Department of Biology, is program chairman.

Industrial educational activities were achieved through the Special Summer Course Program at MIT. In Fiscal 1994, six special summer courses under the auspices of the BPEC were presented. They were, "Biotechnology Principles and Processes"; "Fermentation Technology"; "Downstream Processing"; "Controlled Release Technology"; "Modeling, Simulation and Optimization of Chemical Processes"; and "High School Science Teacher Program." BPEC faculty taught six mini courses on site and two mini-courses at industrial sites. The center held two workshops on-site and two off-site.

CURRENT RESEARCH

The vision and goal of this ERC are to develop advanced ideas for the manufacturing of complex proteins and to train a new breed of professionals with the cross-disciplinary skills needed to support the biotechnological industry. Many therapeutic proteins cannot be made in prokaryotic organisms and thus new ideas are needed to synthesize and recover these materials from animal cell cultures.

The research thrusts of the BPEC are designed to solve near and long term problems, and as such, have affected the United States biotechnological manufacturing capabilities and international competitiveness. Training people, performing research, and working with industry, are central BPEC goals and is the mechanism through which we will deliver the benefits of our work.

As mentioned above, two research thrust areas are being pursued at the center. The first area is focused on the "Engineering and Scientific Principles in Therapeutic Protein Production." Research in Thrust Area I focused on both performance and optimization issues of the cell-bioreactor system employed for product synthesis. As such, projects in this area were naturally divided between the fields of genetics and molecular biology, on one hand, and bioreactor design and operations, on the other. In recent years, however, it has become apparent that research in this area can be facilitated in a different organizational structure, specifically by reorienting research projects along
with interdisciplinary thematic lines believed to be the core of the current protein manufacturing processes. In response to this realization, the projects in Thrust Area I are reorganized into the following research themes: Cell Physiology and Cell Metabolism; Post-Translational Protein Processing, Glycosylation and Regulated Secretion; and Bioreactor Systems. This reorganization was implemented during the past year and it reflected a shift of emphasis towards cell viability, critical protein modifications and bioreactor environment as the defining elements of the quantity and quality of the final product. The reorganization was the outgrowth of cross-disciplinary collaborations spanning a period of eight years and three scientific disciplines.

The second thrust area is focused on "Integration of Process Engineering and Science of Therapeutic Protein Interactions and Stability." Thrust Area II is now strategically focused to direct its research and development efforts toward Protein Interactions and Protein Stability and Formulation.

Our strategic plans for the future in this sub-thrust are directed toward the interrelationships between biology and engineering in bioreactor systems. More specifically, the goals are directed toward metabolic pathway analysis, biochemistry and cell physiology in the rational design of animal cell media and control strategies for increased productivity and protein quality. This new focus also becomes a natural interface with bioanalytical developments for on-line and real time monitoring in cell cultures leading to rational bioreactor control systems.

The goal in manufacturing therapeutic proteins is production of very pure, homogeneous and fully functional protein preparations. A few engineering problems in achieving this goal originate in upstream manufacturing, e.g., heterogeneity in post-translational processing, insoluble aggregate formation, impurity and contaminant introduction. Many other problems develop during the downstream process, e.g., specific and nonspecific surface interaction, solution and solid phase stability, variable refolding, and aggregation during refolding. The mission of the center is to establish the relationship between the bioprocess environment on one hand, and process yield and product quality obtained from protein purification on the other. To accomplish this mission, center research must develop the science base underlying the observed phenomena. It must also aid in the application of the knowledge to the improvement of product purification operations.

INDUSTRIAL COLLABORATIONS AND TECHNOLOGY TRANSFER
Industrial collaborations and technology transfer are important goals of the center. In 1986, our Industrial Consortium Program was established with a membership of 38 companies. The Consortium had a membership of 66 companies in Fiscal 1994, representing the entire spectrum of the biotechnology industrial sectors. During this period a total of 137 companies have interacted with the center, of which 117 are U.S. companies. As an example of the type of interactions that took place the center was involved with 48 collaborative industrial projects. Lastly, during Fiscal 1994 there were seven industrial scientists and engineers in residence at the center.

As part of BPEC's effort to foster technology transfer, it has established an Industrial Consortium Office. Its responsibilities include coordinating company visits; distributing research abstracts, published papers, and student theses; organizing workshops and symposia; and maintaining a database of BPEC research projects. This office works closely with the BPEC faculty, BPEC students, the MIT Industrial Liaison Program, and the MIT Technology Licensing Office in order to serve company needs.

Research topic oriented workshops play an important role in BPEC's technology transfer program. By bringing company representatives together to discuss a common topic, these workshops provide a forum for education and company-company interactions. The BPEC has held workshops on the following topics: animal cell science and technology, downstream processing, process control and scale-up, advance in membrane technology for bioprocesses, bioinstrumentation, industry regulation, protein expression systems, bioremediation technology, biosensors, and proteins on pharmaceuticals. Typically, these workshops draw approximately 30 to 50 attendees from 20 to 30 companies. The center has also attempted to hold these meetings at locations other than MIT, so as not to create a geographical bias toward certain companies.

The center has been quite productive during fiscal 1994. Personnel have produced 271 publications, given 109 presentations, participated in 47 industrial and 60 university seminars, produced 21 theses, and met with visitors from 67 different U.S. companies. Many of these visits led to collaborations between the BPEC and the company.

Daniel I. C. Wang, Director
The Center for Advanced Engineering Study (CAES) was founded in 1963 for the purpose of developing educational programs that provide opportunities for practicing engineers, scientists, and managers in industry, government, and educational institutions to attain and maintain the competence needed to exert technological leadership. Alfred P. Sloan, Jr. provided both the impetus and the funds to get the center started. Building 9 has been the home of CAES since its completion in 1968.

To achieve its objectives, CAES has traditionally offered two types of educational programs at the workplace and on campus for practicing professionals. For those at the workplace, the center provides studio-based and classroom-based video courses, directed by Richard Noyes, which are produced at the center in collaboration with MIT faculty and research staff. The on campus Advanced Study Program, directed by Dr. Paul E. Brown, provides the participants with individualized study and/or research that is tailored to their backgrounds and designed to meet their needs and the objectives of their employers.

During the 1993-94 academic year, 68 professionals participated in the Advanced Study Program, 20 from the United States and 48 from 11 other countries. These fellows attended regular graduate and undergraduate subjects that suited their needs. In addition, many of them performed individualized studies guided by faculty members and several participated in ongoing research programs. Also, the center sponsored several subjects that are of particular interest to the fellows, such as Project Management and Management of Technological Change. These subjects are listed in the MIT course catalog and are, of course, open to MIT students. CAES, in addition, offered informal evening classes in English as a Second Language.

The fellows in the Advanced Study Program are provided with study offices, computer facilities, and a videotape library with viewing facilities. The computer facilities include IBM, DELL, and Macintosh computers, and DEC VAX workstations and SUN SPARCstations connected to the Athena Network, which integrates computers into the educational environment in all fields of study. The center also offers a weekly luncheon seminar at which the Fellows give brief presentations of their work. Center staff and faculty also make presentations at these seminars.

CAES Video Courses extend the on campus academic program through the distribution of video-based education. CAES has produced more than 75 in-depth, high quality video courses in engineering, science, and management. Each course, taught by a leading authority in the field, is designed specifically for use by professionals at the workplace. Recent video course releases include Understanding Lasers and Fiber Optics by Professor Shaoul Ezekiel, Designing Products that Sound Good by Professor Richard Lyon, Fault Tolerant Control Systems by Professor Wallace Vander Veld, Management of Technological Change by Professor Ernst Frankel, and Object-Oriented Systems by Professor Duvvuru Sriram.

The center operates a professional-level studio complex in its headquarters in Building 9. Broadcast-quality, multi-camera recording and editing equipment is used in the production studio, as well as in-classroom courses and symposia. Courses in development include Machining Skills for Prototype Development by Dr. Erik Vaaler, A New American TQM by Professor Shoji Shiba, and Principles of Reliable Measurement by Professor R. John Hansman.

CAES is also developing a coherent curriculum in total quality management with The Deming Videotapes and Dr. W. Edwards Deming's textbooks at its base. The second edition of The New Economics is in development. Also, scripts are being written for audio tape versions of Out of the Crisis and The New Economics. Other courses include Statistics in Quality and Productivity, Concurrent Engineering, Taguchi Quality Engineering, Enhanced Quality Function Deployment, House of Quality, Lean Production, and Managing Innovation Through Lead Users.

The center works closely with the faculty in the development of innovative educational programs. The selection of topics and the breadth of the coverage are influenced by industry needs. The coupling between CAES and the MIT campus is also strong. Most video courses produced by the center are available at the MIT libraries for use by students, faculty, and staff.

A variety of multimedia programs are also being developed at CAES using the center's recently completed interactive multimedia suite. One program in development is Engineering Design Instructional Computer System (EDICS). Through a collaboration with the Department of Mechanical Engineering and the Center for Educational Computing Initiatives, CAES is creating EDICS as an interactive multimedia program that will be delivered in the CD-ROM format. CAES plans to create additional interactive multimedia programs for distribution on CD-ROM disks to industry and educational institutions. For example, Video Demonstrations in Lasers and Optics by Professor Ezekiel is being
converted to an interactive laser disc format. Multimedia development is conducted in the CAES multimedia facility in Room 9-250.

In the interest of utilizing innovative delivery systems and broadening the availability of multimedia information services, CAES is pursuing the delivery of a variety of compressed, digital video programs over the National Science Foundation (NSF) fiber-optic network. Initial funding of this program will be from NSF/ARPA and most of the hardware will be provided by IBM. Other groups at MIT and at Carnegie Mellon University will address infrastructure architecture, services, standards and policy issues.

The MIT Video Productions group continues to provide a full range of affordable high quality services for the Institute. Any Institute video need can be fulfilled efficiently and at a reasonable cost at any campus location and at the CAES television studio. A recently acquired PictureTel videoconferencing system is now available as an additional service by CAES. PictureTel simultaneously transmits both audio and compressed digital video information via telephone lines to up to 16 contact points, and is used for long distance meetings, presentations, remote instruction, and consultations worldwide. MIT Video Productions facilities and services include, among others, a full production television studio, a television classroom, videotaping on location, on-line and off-line editing, plus videotape duplication. The recent completion of the renovated studio control room with full Beta SP recording keeps CAES at the cutting edge of broadcast quality television.

SHAOUL EZEKIEL
The focus of the CTPID is understanding the policy implications of large-scale, complex systems subject to conflicting economic, technical, environmental, and social objectives (e.g., global environmental control of greenhouse gases, communication and computer-based information systems, and international industrial competitiveness in selected industries). By undertaking comparative research and cross-cutting studies between projects, faculty can better understand and perhaps improve the policy-making process.

Fundamental to the success of CTPID is the commitment of a core group of faculty to devise the mechanisms—the joint research projects, the educational programs, the interdisciplinary connections, and most importantly the enthusiasm—to engage a broader group of faculty and students in discussions and thinking about technology and policy. We have already made modest strides toward this goal. Senior faculty and staff, including Professors Roos, Marks, Ashford, deNeufville, Ruina, Weiss and Clark and Dr. Ehrenfeld (SRA) and Tabors (SRA) of the Engineering School and Professor Fine of the Sloan School have made the CTPID the base of their research operations.

The educational arm of the CTPID is the Technology and Policy Program (TPP). During the past year, faculty associated with TPP have been developing a sequence of multidisciplinary subjects in the School of Engineering in Large Scale Systems Design, that are creating school-wide teams of faculty. It is expected that they will form a coherent faculty group both for TPP and for parallel departmental efforts to create practice-oriented master’s degree programs. The number of students enrolling in the TPP Master’s program has also grown significantly, by about 20%. TPP now has over 100 students on campus, up about 50% from three years ago.

Research volume in the CTPID grew by almost 50% from FY93 to FY94. In a new initiative the Technology, Business, and Environment Program organized two environmental management conferences in 1993. The conferences brought together senior people from industry, government, and academia to inform and coordinate action in two areas:

Design and Disposal of Durable Products. This conference, held in March 1993, assessed the strengths and weakness of the different approaches to fostering “green” durable products. “Green” products are products whose manufacture, use, and disposal cause minimum damage to the environment. Conference sessions included presentations from leading U.S. and European manufacturers in the auto and electronics industries, a U.S. Senate committee staff member, and an environmental advocate. One outcome from the conference was a set of recommendations, developed by participants, to guide U.S. policymakers working in this area.

Life Cycle Assessment. Life cycle assessment (LCA) is a tool to identify opportunities to reduce environmental impacts associated with all phases of a product’s “life”--from production or manufacture, through use, re-use, or recycle, to waste processing and disposal. This conference, held in November 1993, explored the value of LCA as a practical tool for establishing environmental practices in businesses. The conference featured seven case studies of leading LCA practitioners. Building upon case studies and participants’ experience, conference discussions identified and attempted to resolve the major issues that limit the potential for life cycle approaches to promote lasting and significant change.
The CTPID is continuing to set goals for the appointment of minorities and women in research or other academic positions. One of the significant results from these efforts was Professor Kaye Husbands' appointment as Visiting Scholar in the International Motor Vehicle Program. Professor Husbands, an Afro American female, comes to the program from Williams College where she is an Assistant Professor of Economics.

In seeking to fill positions, a vigorous search and systematic efforts are made to insure that minorities and women have adequate opportunity to be considered. Senior faculty and staff associated with CTPID are excited about the possibility of creating a new organizational structure that will allow us to improve our effectiveness in teaching and conducting research in technology and policy activities.

Joel Clark
Daniel Roos
INTRODUCTION

The Center for Transportation Studies was established in 1973 to develop and coordinate the wide range of transportation-related activity at MIT. It provides a focal point for transportation education, facilitates transportation research, conducts an outreach program to the transportation industry, and encourages a sense of common purpose among the many departments, centers and laboratories involved in transportation at MIT.

EDUCATION

Because of intensified marketing efforts (including a second annual Transportation Open House in conjunction with the MIT UTC program), applications for graduate studies in transportation have increased significantly. This year, 80 applications were received with a higher proportion of US applicants than ever before. Because the quality of applications remains consistently high, qualifying for admission is increasingly difficult. Last fall 20 students were admitted -- funding was found for more than 75% of them -- and about the same number are expected this fall.

RESEARCH

During the past academic year, 159 projects were listed in the Center's Current Research Projects in Transportation at MIT, 46 of which were started since last year's listing was printed. Annual sponsored research volume continued its long-term growth to a level of $5.7 million in fiscal year 1994.

The Region One University Transportation Center. In 1988, MIT was named one of ten universities to take the lead in establishing a four-year, $40 million program for the US Department of Transportation. Since the inception of the program, the Region One center has selected 82 projects for funding in New England through a peer review process, involving a total of 95 faculty researchers. It has funded 21 highway projects, 18 IVHS projects, 21 transit projects and 22 multimodal projects while providing 66 fellowships and 53 research assistantships -- a total of 119 student assists. Last year, as a result of the success of the UTC program, funding was extended by Congress (through ISTEA/1991) for another six years. This year the program continues with yet another $1 million matching grant.

The Center also continues its involvement in a major multi-year contract with the Massachusetts Highway Department, through its management consultant Bechtel/Parsons Brinckerhoff, to refine the design of an integrated project control system for Boston's Central Artery/Tunnel Project (CA/T). The contract is with MIT's IVHS Research Program, a joint effort of the Center with Lincoln Laboratory, the Man Machine Systems Laboratory and the Intelligent Engineering Systems Laboratory.

PUBLIC AFFILIATES PROGRAM

This year, the Center inaugurated a Public Affiliates Program, an international, multimodal effort designed to provide a structure for discussion, research and cooperative problem-solving among the public leaders in the transportation sector, at all levels of government. Based upon the Center's success with its corporate affiliates program, it will offer opportunities for public agencies to participate in the latest research, to share experiences with colleagues in other countries and at different levels of government, to network on implementation issues, and to cultivate opportunities for benchmarking programs and processes. Most importantly, the program will develop new research topics and new styles of cooperative research undertakings among the participants, as well as between participants and the private sector.
corporate affiliates. The program will also contribute to MIT's educational programs by offering students direct access to participating agencies through internships, case studies and joint thesis supervision. As of this writing, the program has committed eight charter members: Federal Highway Administration, Washington DC; Colorado Department of Transportation, Denver CO; Indiana Department of Transportation, Indianapolis IN; Massachusetts Department of Transportation, Boston MA; Pennsylvania Department of Transportation, Harrisburg PA; New Jersey Department of Transportation, Trenton NJ; Washington Metropolitan Area Transit Authority, Washington DC; Vermont Agency of Transportation, Montpelier VT.

MAJOR MEETINGS

World Economic Forum. As part of the Industry Summit held at MIT last fall, the Center for Transportation Studies organized five transportation and logistics sessions on a range of high-priority issues. The meetings featured top officials from shippers and carriers in the US, Europe, Japan, Mexico, Canada, India and South Africa, as well as government officers including the US secretary of transportation, the deputy secretary, the federal highway administrator and deputy administrator, and the secretary general of the European Conference of Ministers of Transport. The transportation and logistics sessions focused on: The Challenge of Integrated Supply Chains; Trends in International Transportation; The Changing Government Role/US Policy and Issues; The Changing Government Role/Privatization; The Impact of Information Technology on Logistics and Transportation. The event included a dinner Friday night at Boston's Gardner Museum hosted by Kent Nelson, chairman of the United Parcel Service, and featuring speaker William Koch, president of the Oxbow Corporation and winner of the 1992 America's Cup. Saturday's activities included a State House reception and a Boston Pops concert at Symphony Hall in conjunction with the rest of the forum participants.

Transportation, Economic Growth and the Environment. The inaugural meeting of MIT's new Public Affiliates Program was held February 24 and 25 at the Institute's Faculty Club. The meeting brought together more than 90 people from both the public and private sectors, including representatives of over 30 public agencies interested in membership, for a series of panel discussions on transportation, economic growth and the environment. The primary sessions focused on The Interaction of Transportation and Economic Growth; The Interaction of Transportation and the Environment; The Role of Technology; and Institutional Mechanisms. The keynote address was delivered by Fred Salvucci, senior lecturer at MIT and former secretary of transportation in Massachusetts.

Using IVHS for Commercial Vehicle Operations. On March 17, a day-long meeting was held at the MIT Faculty Club to assess commercial vehicle operations as a 'first frontier' for the implementation of intelligent vehicle/highway systems. Attended by more than 70 representatives of the public and private sectors and of academia, the seminar was the first of a series to be offered through MIT's new Public Affiliates Program. The meeting was successful in many ways -- there was a strong turnout of participants; both the public and private points-of-view were well presented; and there was a good start on developing public/private partnerships: by the end of the day, Matt Edelman, Chairman of the Steering Committee for the 1-95 Corridor Coalition, had business cards in hand from four private participants who were interested in learning more about the coalition's efforts in electronic toll collection and traffic control.

Shaping the Accessible Region. Almost 500 people from the public and private sectors, and from academia, convened at Boston's Kennedy Library on April 14 and 15 to discuss transportation and economic development priorities for the Boston metropolitan area in the first decades of the 21st century. Modeled on the successful 1984 Boston Conference convened by MIT with the Boston Globe, this year's conference was sponsored in part by the Region One University Transportation Center (headed by MIT's Thomas Humphrey). At the two April meetings, a national jury heard testimony from panels of local experts on how transportation investments in the area might help create regional prosperity. On May 18, the conference concluded with a plenary session at which the five-person jury presented its findings, based on the April testimonies, on how to make the region a national model for integrating economic development and multimodal transportation system investment. The first and second sessions were
broadcast live by New England Cable News; in the fall, the *Globe* will publish a special magazine supplement summarizing the results of the conference. Those results, along with a series of research papers produced in the past year by MIT and Harvard, will provide substantive input to the Boston MPO for subsequent analysis and plan development.

**Activity-Based Costing.** A two-day meeting was held June 2-3 on activity-based costing in logistics and transportation. In traditional costing systems, overhead costs are often allocated based on labor costs or machine hours, but because of changes in the business environment a much larger portion of total costs now are overhead costs, and therefore more important. By looking at the activities that drive the overhead costs, activity-based costing helps managers make more informed decisions with regard to product costs. One hundred twenty-two participants from 43 organizations took part in the meeting. Presenters at the meeting included Paul Healy and Fred Kofman of the Sloan School. The keynote address was given by Arnoldo Hax, Alfred P. Sloan Professor of Management at MIT.

**SMALLER FUNCTIONS**

**IVHS America Meeting.** This past July, MIT hosted a 1-1/2 day meeting of the Coordinating Council of IVHS America. IVHS America is a federal advisory committee of about 400 members charged with providing advice to the US Department of Transportation on IVHS matters; organizations from academia, and from the public and private sectors, participate in its annual meetings and various committees. From an historical point of view, the meeting was a homecoming for many -- a number of the council's 40 members are MIT alumni. The meeting was a homecoming in another sense, as well -- in the late 1980s, when Mobility 2000 was just getting formed as a precursor to what later became IVHS America, they also met at MIT. An informal organization that Joseph Sussman helped found, the Mobility 2000 group, met to determine what could be learned from the experiences of the air and rail industries. Sussman later spent a year (1991-92) as a distinguished academic scholar in residence in Washington working on the strategic plan for IVHS America.

**ATIS Workshop.** Last fall, a day-long workshop was held at MIT to address questions concerning user response to Advanced Traveler Information Systems (ATIS). By using the latest technology to provide traffic information and navigation aid to travelers, assisting in pre-trip and en-route decisions, ATIS have the potential for helping produce faster, safer, less anxious trips; but to ensure the efficient implementation of ATIS, and to enable evaluation of their benefits, a proper understanding of user response is still needed. The workshop -- sponsored by the Volpe National Transportation Systems Center and the Federal Highway Administration -- was designed to gain insight into user response to traffic information provided through ATIS systems, and into the public's willingness to pay for such services. The meeting's overall objective was to bring together simulator developers with those involved in operational field tests to determine which sort of data collection and tests are the most fruitful to pursue. About 35 people attended, representing 16 organizations.

**Seminar on Defense Conversion.** Over 100 people attended a meeting at MIT in October to focus on defense conversion and the applications of those technologies to transportation. Sponsored by the Center in collaboration with the US Secretary of Transportation, the meeting was designed to help identify key transportation research and development needs that are amenable to technological solutions. The event consisted of panel discussions on the linkage between transportation and the environment, infrastructure, rehabilitation and maintenance, and new vehicle technology. Leaders in industry, small businesses, national laboratories, academia, state and local government and community development took part.

**Symposium on Environmental Strategies.** Sixteen members of the Center's corporate affiliates program attended a day-long symposium on Proactive Environmental Strategies at MIT November 17. The meeting was sponsored by the MIT Industrial Liaison Program, the MIT Program for Environmental Engineering Education and Research (PEEER) -- of which the Center is a part -- and the Council for Global Environment. More than a dozen sessions were held, covering generic problems and approaches for anticipating the environmental future, and their implications for education, as well as examples of
industry-specific strategies in the chemical, electronics/computer, construction, polymers, chemical process and basic metals industries. Corporate affiliates represented were AT&T, Conrail, Digital Equipment, Dow Chemical, DuPont, Federal Express, Flota Grancolombiana, Maersk, PPG, Sea-Land and UPS.

Inventing the Organizations of the 21st Century. To deal effectively with the challenges of increasing competitive pressures, social and political changes and advances in information technologies, organizations will need to learn more about systems thinking, human interaction and coordination processes. As part of their movement in that direction, 16 representatives of the Center’s Corporate Affiliates Program attended a two-day meeting this May to learn how information technologies are actually changing the structural possibilities for organizations, and how organizations can engage in the kind of learning that will be required to take advantage of those possibilities. Sponsored by MIT’s Center for Coordination Science, Organizational Learning Center and Industrial Liaison Program, the symposium included presentation and discussion of possible organizational scenarios to help in understanding the actions needed today to create the organizations of tomorrow.

INDUSTRY AFFILIATES PROGRAM

New Affiliates Bring Membership to 39. The Corporate Affiliates Program welcomed several new members this year, bringing the current total membership to 39. The new members are British Air; British Rail; Chemical Leaman Tank Lines; NYK Line (North America); Procter & Gamble; Yellow Freight; and the Sema Group. Continuing members are American President Lines; AT&T Bell Laboratories; Atchison, Topeka & Sante Fe; Bose; Burlington Northern; Canadian National Railway; Caterpillar; Consolidated Freightways; Conrail; CSX; Digital; Dow; DuPont; Encompass; Federal Express; Flota Mercante Grancolombiana; Gillette; Goodyear; IBM; LogiCorp; Maersk; Norfolk Southern; Roadway Services; Ryder System; Sea-Land; The 3M Company; Unilever; Union Pacific; UPS; US Postal Service; USX; and Xerox.

Affiliates Day at Goodyear Tire & Rubber. Every year, as part of the Center’s Corporate Affiliates Program, one of the members hosts the rest of the group at a two-day meeting and tour of one of its facilities. In the past, meetings have been hosted at sites ranging from the dining car of a moving train to the drydocked Queen Mary. This year’s meeting, hosted by the Goodyear Tire and Rubber Company at its Ohio headquarters, focused on post-sale value-added concepts and introduced affiliates to the logistics operations of one of the world’s leading tire manufacturers: in the US alone, Goodyear spends about $280 million a year on distribution costs, making about 4000 shipments a day, with an annual global figure of about $600 million. The meeting, attended by 50 representatives of 27 organizations, included an address by Stan Gault, Goodyear’s chairman and CEO, talking about the firm’s dramatic economic turnaround and about his meeting the previous day with President Clinton.

LUNCHEON SEMINAR SERIES

Every year, the Center sponsors a luncheon seminar series featuring transportation experts from the public and private sectors, and from academia, discussing current issues in the transportation field. Open to the public-at-large, the seminars draw an audience made up of students and faculty from the Institute, and the local business, government, and academic communities. Attendance has grown substantially over the last several years as this monthly event has gained prominence on the MIT calendar and that of the local transportation community. This year’s speakers were: Grace Crunican, Deputy Administrator of the Federal Transit Administration, spoke September 24 on intermodal land use; Jane Garvey, Deputy Administrator of the Federal Highway Administration (FHWA), spoke October 8 on the promise of ISTEA; Kathleen Strange, Vice President of Logistics at the Stride Rite Corporation, spoke October 29 on logistical issues of site selection; Peter Stangl, Chairman and CEO of The Metropolitan Transportation Authority, spoke November 12 on change in the transit industry; Mortimer Downey, Deputy Secretary, US Department of Transportation, spoke December 3 to a crowd of 80 people on the
goals of the Clinton administration in terms of transportation; Frank Lorenzo, former chairman and chief executive of Continental Airlines, now chairman of Savoy Capital, a private investment firm, spoke at MIT March 4 on "The Airline Consumer in the 90s"; Andrew Card, Secretary of Transportation under President Bush and currently President and CEO of the American Automobile Manufacturer’s Association, spoke at MIT March 18 on "The Automobile and Personal Mobility"; Walter Riley, President of Guaranteed Overnight Delivery (G.O.D.), spoke at MIT April 22 on "Expedited Service -- Air Freight Agents Combined with Trucking"; John J. Haley, Jr., General Manager of the Massachusetts Bay Transportation Authority, spoke at MIT May 6 on "Building Better Service: Nothing Else Matters."

PROFESSIONAL EDUCATION

Logistics Analysis Offered for Tenth Year. Over 50 people from 38 different carriers, shippers and third-party logistics providers attended a one-week intensive course last summer on Logistics Analysis for Carriers and Shippers. Because members of the affiliates program are entitled to one free enrollment each year, and those who have attended often send colleagues in succeeding years, the course was oversubscribed as always. While this was the tenth year the course has been offered, the course material is changed every year to take advantage of new knowledge and to address the most current questions. As always, however, the course was structured around a series of lectures and case studies and involved intensive interaction among the participants.

FACULTY AND STAFF

Sussman Heads Executive Committee of TRB. JR East Professor Joseph Sussman, Professor of Civil and Environmental Engineering, was appointed Chairman of the Executive Committee of the Transportation Research Board (TRB) for 1994. TRB is a unit of the National Research Council, the principal operating agency of the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public and the scientific and engineering community. Its mission is to stimulate research concerning the nature and performance of transportation systems and to disseminate and encourage the application of research results. In 1994, its annual meeting in Washington DC attracted over 7000 people, making it by far the largest transportation research conference in the world. Sussman is the first MIT faculty member to serve in this capacity.

New Staff. Mary Gibson joined the Center’s staff as Manager for Administration and Finance. Previously Manager of Software Acquisition at MIT Computing Support Services, before that she held positions as Manager of Administration and Finance for Project Athena, and as a budget officer at MIT’s Office of Financial Planning and Management. Also joining our staff was Nancy Martin, an administrative assistant working with Deputy Director Peter Metz. She was previously an administrative assistant in the office of undergraduate education and student affairs, and at the Gas Turbine Lab in MIT’s Department of Aeronautics and Astronautics.

Student Contribution. David Cuthbert, a recipient of the Master of Science in Transportation in May, was awarded a Karl Taylor Compton Prize this spring by MIT in recognition of his contributions to campus transportation and safety; he also received an award from the campus police for his work with SafeRide. Cuthbert worked with a class of freshman transportation students to analyze the SafeRide service and design a prototype schedule, and also played a key role in starting a student safety escort and patrol service to augment SafeRide, called SafeWalk -- an on-demand service for students working late who want to travel somewhere on campus not covered by SafeRide. He also took it upon himself to conduct a student survey, the results of which will be used by the GSC to campaign for an expanded transportation service. And he started a student shuttle to the Star Market in Medford that ferries 35-40 students a week.

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

Founded as Project MAC in 1963, the Laboratory developed one of the world's earliest time-shared computer systems. This early research on the Compatible Time Sharing System (CTSS) and its successor, MULTICS, made possible in the 60s and early 70s innovative developments such as the writing of operating systems in high-level programming languages, virtual memory, tree directories, on-line scheduling algorithms, line and page editors, secure operating systems, concepts and techniques for access control, computer-aided design, and two of the earliest computer games, space wars and computer

These early developments laid the foundation for the Laboratory's work in the 1970s on knowledge based systems -- for example, the MACSYMA program for symbolic mathematics -- natural language understanding, and (with BBN) the development and use of packet networks. During this same period, the Laboratory developed theoretical results in complexity theory and linked cryptography to computer science through concepts and algorithms for public encryption (RSA). In the late 1970s, Project MAC, renamed as the Laboratory for Computer Science, embarked on research in clinical decision making, public cryptography, distributed systems and languages and parallel systems. These led to the RSA encryption algorithm, data abstractions, the CLU and ARGUS distributed systems, the dataflow principle and associated languages and architectures of parallel systems, local area ring networks, program specification and workstation development, where the Laboratory contributed the earliest UNIX ports and compilers, and the Nubus architecture, now used in commercial computers, such as Apple's Macintosh II. This research has also led to the X Window System, a computer intercommunication and user interface approach, developed together with Project Athena and widely used by industry.

The Laboratory's current research falls into four principal categories: Information Infrastructure and Distributed Systems; Human Interaction/Intelligent Systems; Computationally Intense Systems; and Theory. The principal technical goals of these four categories are as follows:

In the areas of Information Infrastructure and Distributed Systems, we wish to establish principles and pursue technologies for constructing and using information infrastructures from the organizational to the national level. Transactions among distributed systems are likely to involve beyond conventional electronic mail and file transfer, the purchase and sale of information and information services, including electronic shopping, group work across space and time, and so on. The requisite technologies involve communication among programs through common conventions, storage in persistent object-oriented repositories and the sharing of data among such programs; security, and interactive use of high-quality video and sound together with text and graphics. This research is expected to have a broad impact on future systems because virtually every machine will be connected to some information infrastructure.

In the Human Interaction/Intelligent Systems area, our technical goals are to understand and construct programs and machines that have greater and more useful sensory and cognitive capabilities so that they may communicate with one another and with people toward useful ends. Examples include interactive spoken dialogue between people and machines, including multi-lingual and multi-modal approaches, i.e., the use of speech, typing and mouse movement -- all toward communicating the same concept. This area also includes programs that reason about clinical issues and help in clinical decision making.

In the Computationally Intense Systems area, we strive to harness the power and economy of numerous processors working on the same task. Research in the area involves the analysis and construction of various parallel hardware architectures, programming languages and operating systems that yield, over a broad set of applications, cost-performance improvements of several orders of magnitude relative to single processors. We are also carrying out research on the uses of computationally intense systems in several application areas for the purpose of improving architectures and programs that we develop, based on their utility.

Taken together, these three thrusts in infrastructure, human interaction/intelligent systems and parallel systems define the Laboratory's overarching goal: development, understanding and better human communication with tomorrow's computer systems which we envision to be multiprocessors interconnected by information infrastructures as ubiquitous and as important as today's telephone and highway substrates.

In the Laboratory's fourth category of research, Theory, we strive to understand computer systems and discover the fundamental forces, rules, and limits of Information Science and Technology. As a result, theoretical work permeates our research efforts in the other three areas: for example, in the pursuit of parallel algorithms, fault tolerant computer networks, and privacy and authentication of communications. Theory also touches on the logic of programs, the inherent complexity of computations, and the use of cryptography and randomness in the formal characterization of knowledge. The Laboratory expends a great deal of effort in theoretical computer science because its impact upon our world is expected to continue its past record of improving our understanding and helping us pursue new frontiers with new models, concepts, methods, and algorithms.

Research highlights during the reporting period are as follows:

1. Substantial progress in the Laboratory's various multiprocessor architectures: (1) Professor Arvind's group, in collaboration with Motorola, has built and installed the Monsoon Dataflow multiprocessor at 6 sites. These research prototypes are being used primarily for developing implicitly parallel programs written in Id. The group is currently engaged in building with Motorola the *T (StarT) parallel machine, using a Power PC 620. *T is likely to become a commercial product. (2) The MIT Alewife machine became operational.
Alewife's unique features include the integration of message passing and shared memory into a single coherent interface, and a software coherent shared-memory called limitless directories.

2. Enhancement of the video kit developed by Professor Tennenhouse's group, whereby, for example, remote users from any part of the world can drive a video cam equipped vehicle within our Laboratory, viewing on their screens the places that this "rover" visits.

3. Expansion and integration of the Laboratory's Spoken Language Systems with air reservation systems, the yellow pages, weather and city map databases. This permits the creation of new spoken dialog-oriented advisory systems that let a user book flights, find out about the weather at the destination, locate the place to be visited, see it on a map, and, in general, conduct travel planning as if by speaking to several knowledgeable advisors.

4. Project SCOUT is an LCS led consortium designed to promote interaction between computer and computational scientists in the areas of parallel computing, includes participants from Harvard, Boston University, and various MIT departments. Using the SCOUT facilities which includes a 16 GigaFlops CM5 computer, Professors Arvind, Leiserson, Kaashoek, and Weihl of LCS and their students and staff made novel contributions in the areas of heuristic and combinatorial search, efficient run-time schedulers, optimistic active messages, split phase synchronization, and languages for multithreaded computing. Outside of LCS and using some of the above advances, Professor Tanaka and his student were first to compute all possible protein configurations (self-avoiding random walks) on a 3x3x4 and 3x4x4 lattice. Modeling activities included Professor Berger on icosahedral plant and animal virus growth, Professor Hastings on backflow contamination of ion-thrusters onto spacecraft, Professor Marshall on the oceans, and Professor Negele on quantum chromodynamics.

During this reporting period, the Laboratory's Distinguished Lecturer Series included presentations by A.G. "Sandy" Fraser, Executive of Research, Information Sciences Division, AT&T Bell Laboratories, Professor Henry Fuchs, Department of Computer Science, University of North Carolina, Professor Edward D. Lazowska, Department of Computer Science and Engineering, University of Washington, and Dr. Joel S. Birnbaum, Vice President, Research and Development, Hewlett Packard.

The Laboratory is organized into 21 research groups, an administrative unit, and a computer service support unit. The Laboratory's membership includes a total of 491 people, including 91 faculty and research staff, 45 visitors, affiliates, and postdoctoral associates and fellows, 39 support staff, 195 graduate students, and 121 undergraduate students. The academic affiliation of most of the Laboratory's faculty and students is with the Department of Electrical Engineering and Computer Science (EECS).

About one half of the Laboratory's funding comes from the US. Government's Advanced Research Projects Agency. The Laboratory is also funded by and has extensive links with industrial organizations. These include partnerships for the construction of major hardware systems, consortia for the development and maintenance of standards, such as X Windows, and joint studies on research areas of common concern.

MICHAEL L. DERTOUZOS
INTRODUCTION

The mission of the Laboratory for Electromagnetic and Electronic Systems (LEES) is to be the focus for research and teaching in electric energy from its production through its processing to its utilization, and in electromechanics from the macroscopic through the microscopic to the molecular levels. Electric energy and electromechanics are defined broadly to include power systems monitoring and operation; automatic control; power electronics; high voltage engineering; and conventional, continuum and biological electromechanics. Much of the work of the laboratory is experimental, and industrial sponsorship represents a large fraction of the laboratory’s support. The laboratory’s professional staff consists of 11 faculty from EECS, 2 Senior Research Engineers, 11 research staff, and approximately 60 graduate students. The laboratory faculty and most of the staff are heavily involved in both undergraduate and graduate teaching. Faculty from the departments of ME, CE, MS&E and NE are collaborators in many of the laboratory’s programs, and there are extensive joint activities with the Microsystems Technology Laboratory (MTL), the Energy Laboratory and the Acoustics, Vibration and Machine Dynamics Laboratory (AVMDL). LEES is also an active participant in the Leaders for Manufacturing Program, the New Products Program, and the Program in Technology Management and Policy.

Substantial progress was made during the past year in building up two major new programs in the laboratory - automotive electronics and performance based monitoring and control (PBMaC) of power systems.

PERFORMANCE BASED MONITORING AND CONTROL OF POWER SYSTEMS

The PBMaC initiative introduced last year has generated considerable interest. Commitments of approximately $1M/year to fund this work have been obtained from a combination of the Electric Power Research Institute (EPRI) and individual utilities. PBMaC addresses the technical and economic challenges created by the restructuring of the US electric power industry.

Control

Dr. Marija Ilic, Senior Research Scientist in EECS, and her graduate students have developed new control algorithms and logics for operation of the power system in conditions of greater uncertainty and less information. Drs. Ilic and Richard Tabors, and Prof. Bernard Lesieutre have developed and submitted a set of proposals for further development of economically based control structures. Drs. Ilic and Tabors both prepared documentation for presentation before the Federal Energy Regulatory Commission (FERC) on issues related to operation of the US transmission system under conditions of greater competition. These efforts have led to a number of papers presented during the past year that focus on both the structure and evolution of the US electric power system and on the operations of both the physical and economic system from generation through transmission.

Professors George C. Verghese and Lesieutre and graduate student Ganesh Ramaswamy, working with funding from Electricité de France (EDF), have developed the basis for a new approach to constructing reduced-order dynamic models for large power systems. This work will continue in the next two years, in an effort to consolidate and extend the framework.

Dr. Ilic and her students have completed two research projects – a joint MIT/EDF project on system-wide voltage control and coordination, and an Empire State Electric Energy Research Corporation (ESEERCO) sponsored project on the design of non-linear generator controls for improving energy transfer over long lines.

Adaptive Monitoring of Transformers

Motivated by the concern of utilities for the high costs associated with catastrophic failures of large power transformers, Mr. Wayne Hagman, Research Engineer in LEES, has been developing the technology required to determine their condition while in service. Funding has been received to analyze data generated through the on-line monitoring of several large transformers. This analysis is the logical follow-on to previous work in LEES which produced an adaptive transformer monitoring system. It will verify failure detection hypotheses that have been tested only on data from a small transformer. The next task in this project, for which funding has been received, is to develop an artificial intelligence based diagnostic system, designed to interface with the existing failure detection system, that will both provide information on what the cause of a detected failure might be, and recommend operational actions in response to the detected failure.
Electromechanical Monitoring of Motor Operated Valves
Professor Jeffrey H. Lang and Mr. Hagman, in collaboration with Professor Richard Lyon of the AVMDL, have continued development of a noninvasive performance monitoring system for motor-operated valves (MOVs) in nuclear power plants. The collaborative LEES-AVMDL effort, unique in the industry, is aimed at the noninvasive determination of MOV performance trends through in-service electrical and vibration monitoring of valve operation, and the application of the identified trends to a model-based determination of the valve's ability to operate under design basis conditions. The MIT effort complements present industry and EPRI efforts to predict initial in-service operational requirements. The complementary and innovative nature of the MIT work has continued to attract widespread industry attention. A significant success of this year's effort has been to prove the robustness of modeling and trend analysis techniques previously developed by using a single MOV tested under static (no flow) conditions. The verification was done through the extension of analyses to different motor operator/valve combinations, and the inclusion of flow testing. The generation of data from a valve operated under flow conditions was made possible by the collaboration with EPRI reported last year. With the encouragement of industrial sponsors, we are presently seeking funding to support further flow testing at MIT, the testing of our processing methods on data taken at a host utility nuclear plant, and the design of a prototype MOV monitoring system.

Nonintrusive Load Monitoring
Professor Steven B. Leeb, in collaboration with Professor James L. Kirtley, has filed a patent application for the prototype Nonintrusive Load Monitor (NILM) demonstrated in the laboratory last year. In the next three years, commercialization efforts should begin with EPRI to bring this technology into the field for utilities and commercial and industrial facilities managers. EPRI and ESEERCO have provided additional funding to develop an inexpensive, field portable implementation of the NILM based on a parallel computing architecture. With graduate student Umair Kahn, Professor Leeb has completed prototypes of the components of this new parallel processing system, and is working now to implement a full-scale prototype with recently fabricated printed circuit boards. This prototype will be tested in buildings on the MIT campus during the 1994-95 academic year.

Research during the coming year will be directed at extending the advanced NILM to serve as a platform for performing critical load diagnostics and power quality monitoring. In particular, preliminary experimentation has indicated that it may be possible to nonintrusively diagnose the condition of critical motors in building ventilation systems and industrial manufacturing facilities. The ability to perform nonintrusive diagnostics would provide an inexpensive means for scheduling preventive maintenance on critical path electrical loads.

ELECTROMECHANICS

Computer Aided Design
Professor Leeb and Jacob K. White, Associate Professor of Electrical Engineering, have been collaborating, with funding from the Lincoln Laboratory, to develop accelerated numerical analysis schemes for analyzing electromagnetic systems with spatially-varying permeabilities. These numerical methods, based on the fast multipole algorithm, could result in a ten-fold improvement in computation time in comparison to state-of-the-art software packages currently available. Preliminary work is directed at developing and employing this new CAD tool for the analysis of variable reluctance machines.

Electrical Machines
Professor Lang and his colleagues have made significant progress in the design of motors having a high ratio of torque to mass. In collaboration with Dr. Stephen D. Umans and graduate student Derron Jackson, he has developed a control algorithm which significantly reduces the torque ripple exhibited by the high-torque robotics motor which was designed and reported on last year. In a continuation of the laboratory's activities applicable to electric vehicles, Prof. Lang and graduate student John Ofori-Tenkorang have designed a direct drive wheel motor which they plan to demonstrate during the next year.

Professor James L. Kirtley spent the year on sabbatical as a Visiting Professor at the Institute for Electrical Machines of Eidgenössische Technische Hochschule (ETH)-Zurich, Switzerland. During this time he organized and participated in an international short subject on high performance electric drive systems.

Micro-electromechanics
In collaboration with Stephen D. Senturia, Professor of Electrical Engineering and Dr. David Volfson, Research Specialist in the MTL, Professor Lang and graduate students Eckart Jansen and David Leip have developed a new micromotor with integrated rotor position sensors. Both optical and capacitive sensors have been employed. The new motor is now being tested, and its sensors should soon be used for the purposes of closed-loop motion control.
CONTINUUM AND BIOLOGICAL ELECTROMECHANICS

Physiology of Connective Tissue
Professor Martha L. Gray and her group continued their research in areas which combine biological and physical principles to enable and improve our understanding of connective tissue physiology and disease. They have had recent success in developing microfabricated devices for applications in clinical and biomedical research, collaborative work begun several years ago with Professor Senturia, and currently supported by a start-up company developing DNA sequencing methods. Specifically, in work reported at the recent prestigious Hilton Head Sensors and Actuators Workshop, they have fabricated a flow cell from quartz with integrated optical fibers and have demonstrated important functional capabilities including hydrodynamic focusing and fluorescent particle detection. This work is the first step in enabling the design and fabrication of integrated devices for making optical measurements of living cells (or other particles) in fluid, a capability of interest to a broad community ranging from clinicians to ocean microbiologists.

Professor Gray's other research activities have been devoted to cartilage-related questions. Her group continues to develop and understand magnetic resonance approaches for nondestructive measurement of cartilage composition; this capability has the potential to dramatically influence diagnosis and monitoring of degenerative cartilage diseases. In addition they continue to examine the role of mechanical forces and transport in cytokine-mediated cartilage degeneration, cytokines being strongly implicated as biochemical factors which may promote cartilage metabolism in vivo.

Gel Polymer Actuators
Professor Leeb, in collaboration with Toyoichi Tanaka, Professor of Materials Science and Engineering, and with doctoral candidate Ahmed Mitwalli, has demonstrated small synthetic muscles employing gel polymer fibers as actuators. A critical discovery was made this year which significantly improved key characteristics of these fibers. Inter-penetrated polymer networks of more than one type of polymer have been developed to selectively improve desired characteristics such as strength, stroke length, and response speed. For the first time, force measurements have been made on these fiber bundles, indicating that these actuators exhibit force densities within an order of magnitude of biological muscle tissue. Work is ongoing to improve the strength and reaction time of these actuators, and to characterize their efficiency. A small prototype robotic manipulator employing gel "muscles" will be constructed in the coming year. Preliminary work will also begin this year to construct a Braille tablet for the blind based on gels.

Magnetic Fluids
Professor Markus Zahn and UROP student Donald Greer have solved a new electromechanical analysis examining the conditions for paradoxical pumping of magnetic fluid in the direction opposite to a traveling wave magnetic field.

HIGH VOLTAGE AND INSULATION RESEARCH
Professor Zahn has developed a mathematical formulation using Abel and Radon transforms that allows computation of electric field distributions in non-uniform field geometries from Kerr electro-optic ellipsometry measurements. Preliminary Kerr measurements in transformer oil using point-plane electrodes have been made by Professor R. Hanaoka, Visiting Scientist in LEES. Next year's work will focus on extending the limitations of these electric field/light intensity transforms to allow computation from Kerr electro-optic field mapping measurements of the magnitude and direction of electric field for arbitrary three dimensional electrode geometries.

Dr. Chathan Cooke and his graduate students have been pioneering the use of electrically stimulated acoustic waves as a probe to determine the condition of insulating materials and power apparatus. This technique applied to solid cross-linked polyethylene used in high voltage power cables has shown that there is a distinct charge response to applied stress that is defined by the specific material and the applied stress. A major new project will test full size power cables to determine actual stresses within modern cable materials.

TRANSPORTATION AND AUTOMOTIVE SYSTEMS
Maglev
Professor Richard D. Thornton has been involved for several years in research and development on linear motor propulsion and magnetic suspension for guided ground transportation. He and his students are constructing a model Linear Synchronous Motor propulsion system. This 1/50 scale model of a 300 mph design will allow operation of vehicles on a loop guideway at scale model speeds and with close headway. The focus is on new concepts for position sensing, propulsion winding design, and robust power electronic control.
In collaboration with Draper Laboratory, Professor Thornton is building a test wheel for evaluating linear motors and magnetic suspension systems. The current focus is on high efficiency electro dynamic suspensions and the use of high temperature superconductors for maglev. Another of Professor Thornton’s collaborative activities involves the MIT Plasma Fusion Center and Bechtel Corporation. Together they are studying problems associated with the use of steel reinforcing for maglev guideways. The focus is on predicting undesirable effects due to magnetic fields, particularly the analysis of any degradation of suspension and propulsion performance and effects on the structural integrity of the guideway.

Automotive Systems
LEES has established several new research programs directed at developing advanced technologies for automotive applications. Under sponsorship from Mercedes-Benz, Professor John G. Kassakian and Dr. Tabors, working with graduate student Khurram Afridi, are designing and evaluating new architectures for the electrical distribution system in the automobile. These new designs employ point of load actuation made possible by recent advances in both power electronics and communications. The goal is to reduce system complexity while improving manufacturability, reliability and maintainability.

Under contract from Packard Electric, Professors Martin F. Schlecht, Martin A. Schmidt and Lang have developed the design for a micro-mechanical relay which appears to be well suited for a variety of automotive applications. They plan to demonstrate this relay during the next year.

With graduate students Aaron Schultz and Ahmed Mitwalli, Professor Leeb has developed a 500 W prototype of a battery charging system for electric vehicles employing a non-ohmic, magnetically-coupled connector system. This work, funded by AMP Incorporated, has resulted in the development of power electronic circuit components for a scalable charging system which could be made as large as 10 kW if needed. One of the power supplies in the circuit employs a novel, large-signal linear controller which has been developed in LEES in collaboration with Professor Verghese. This controller enhances the robustness and reliability of the circuit in the presence of wide variations in initial battery voltage and fluctuations in the utility voltage.

POWER ELECTRONICS
During the last year, Professor Schlecht and his students demonstrated experimentally the practicality of Recovered Energy Logic (REL). REL is a logic circuit design in which most of the energy that would have been lost charging and discharging a logic node’s parasitic capacitance is recovered by the power supply. Using MOSFET technology, REL circuits performing logic functions commonly found in microprocessors have been operated as high as 20 MHz with factors of 5 to 8 reduction in power consumption over traditional CMOS. Simulation studies have extended these results to lower voltage levels and higher clock frequencies. Professor Schlecht and his students presented three papers on this technology during the last year.

Professor Kassakian and graduate students David Perreault, Robert Selders and Henrik Martin have been investigating a cellular architecture for large converter systems. They have shown that a significant reliability improvement over conventional designs can be obtained by employing a small amount of redundancy in the system. A hardware prototype converter consisting of 12 cells is expected to be completed and tested within the coming year.

PERSONNEL
Professor Thornton was elected a Fellow of the Institute of Electrical and Electronics Engineers (IEEE).

Professor Verghese was awarded a grant from the Spanish Ministry of Education and Science for a stay in Spain during his sabbatical.

Dr. Cooke, in recognition of his work on dielectrics, has been appointed Convener of a new Conference International des Grands Reseaux Electriques (CIGRE) Working Group on Insulation Monitoring and Life Estimation.

Professor Gray was honored at MIT as the recipient of the Edgerton Award. She also was elected a Member-at-Large of the Board of the Orthopaedic Research Society, an international research organization of clinicians, biologists, and engineers.

Professor Kassakian delivered a series of lectures in the US and Europe under an IEEE Distinguished Lecturer award. He was also elected to the National Academy of Engineering.

John G. Kassakian
The Laboratory for Information and Decision Systems (LIDS) is an interdepartmental research laboratory of the Massachusetts Institute of Technology. Its staff includes faculty members, full-time research scientists, postdoctoral fellows, graduate research assistants, and support personnel. Undergraduate students participate in the research program of the Laboratory through the Undergraduate Research Opportunities Program (UROP). Every year several research scientists from various parts of the world visit the Laboratory to participate in its research program.

The fundamental research goal of the Laboratory is to advance the field of systems, communication and control. In doing this, it explicitly recognizes the interdependence of these fields and the fundamental role that computers and computation play in this research. The Laboratory is conducting basic theoretical studies in communication and control, and is committed to advancing the state of knowledge of technologically important areas.

As an interdepartmental laboratory, LIDS reports to the Dean of the School of Engineering, Professor Joel Moses. The Co-Directors of the Laboratory are Robert G. Gallager, Fujitsu Professor of Electrical Engineering, and Sanjoy K. Mitter, Professor of Electrical Engineering.

The Center for Intelligent Control Systems (CICS), an inter-university, interdisciplinary research center operated by a consortium of Brown University, Harvard University and MIT, resides administratively within LIDS.

Fifteen faculty members, several research staff members and approximately 65 graduate students are presently associated with the Laboratory and the Center. Currently, the Laboratory and the Center provide some 50 research assistantships to graduate students. Undergraduate students also participate in research and thesis activities. A number of postdoctoral and visiting appointments are also made.

Financial support is provided by the National Science Foundation, NASA, the University Research Initiative Program (Army Research Office), Advanced Research Projects Agency (ARPA), IBM, the C.S. Draper Laboratory, the Office of Naval Research, and the Air Force Office of Scientific Research.

NEW RESEARCH INITIATIVES

Coordination in Large Organizations
A new project funded by NSF and involving collaboration with researchers from the University of Connecticut started this year under the direction of Professor Michael Athans. The goal of this project is to develop normative/descriptive models of small and large organizations in which the decision-makers do not have identical information. The paradigm of distributed hypothesis testing is used to assess the performance of different organizational architectures, for both optimal and suboptimal decision rules, and the development of adaptive training algorithms for the organization as a whole.

Identification and Adaptive Control
Determining the fundamental limitations and capabilities of identification and adaptive control has become an active area of research carried out by Professors Munther Dahleh, John Tsitsiklis and Sanjoy Mitter and their students. This newly initiated research program draws upon areas such as information-based complexity theory and computational learning theory as well as upon the theory of robust control.

Machine Learning
In recent years there has been a great deal of interest in the theoretical foundations of machine learning. One goal of this work is to identify the limits of what is and is not possible, such as information theory does for communications or the theory of computation does for computing. One particular framework that has received much attention is a distribution-free model often referred to as the Probably Approximately Correct learning model. The focus of research in LIDS is on analyzing such learning frameworks with a view towards extending their domain of applicability into areas such as machine vision and system identification. Professors Sanjoy Mitter and John Tsitsiklis and their students are involved in this work.

Intelligent Control (Feedback) Initiative
In collaboration with faculty from the Brain & Cognitive Sciences, Professors Athans, Dahleh, Stein and Tsitsiklis started a research project in the area of neural networks. The objective for this initiative is to study the utility of these networks for controller design and system identification. The aim is to quantify the impact of Neural Networks on both adaptive control & hierarchical control. Several S.M. students are currently supported on this project (funded by the National Science Foundation).

Neural Networks, Dynamic Programming, and Reinforcement Learning
The field of neural networks has experienced a dramatic growth, leading to a broad range of commercial applications in many industries. In most applications, neural networks are employed as a powerful function approximation tool, used to solve problems of pattern recognition, nonlinear time series analysis, fault detection, system identification, and process control. In the last few years, a new and exciting application of neural networks has emerged due to a convergence of several ideas from the fields of artificial intelligence, cognitive science, learning theory, and the classical methodology of stochastic dynamic programming. This is the field of "reinforcement learning". It deals with systems that learn how to make good decisions by observing their own behavior and which have built-in mechanisms for improving their actions through a reinforcement mechanism. Reinforcement learning has the potential of addressing
problems that were thought to be intractable due to either the "curse of dimensionality" or the "curse of modeling". These are problems involving multidimensional complex systems that, although easy to simulate, are hard to model exactly and to analyze. Thus there is a broad variety of important problems in many critical areas of national importance, such as logistics, manufacturing, communications, and defense, that can be addressed in this way. Investigations into the theoretical and practical aspects of this methodology and its applications are conducted by Professors Bertsekas and Tsitsiklis, and their students.

**Medical Image and Signal Processing**

Recently there has been great interest in medically related problems brought on by the national debate on health care coupled with the drive to transition the results of defense related research to the civilian sector. Prof. Alan Willsky and Dr. William Karl together with their students have begun looking at the application of statistical signal and image processing methodologies to problems arising in the analysis and evaluation of medically derived data. This work aims to both improve the extraction of information from existing data sources and allow the effective use of emerging technologies for improved diagnosis and evaluation. Specific signal processing problems of interest include improved evaluation of cardiac state and function, correlation of brain morphology and function from MRI data, mammographic screening, and the detection of objects or anomalies given tomographic measurements such as those made using X-rays or ultrasound.

**CURRENT RESEARCH**

**Consortium on Wideband All Optical Networks**

Researchers from LIDS, RLE, Lincoln Laboratory, AT&T Bell Laboratories, and Digital Equipment Corporation have been collaborating for the last several years in developing a universal, wide area, wide band, all optical network. Current funding for the consortium is provided by ARPA. The goal of the consortium is to pursue research and development on optical technologies, architecture, and application interfaces required for a scalable national or international hierarchical network including local, metropolitan area, and wide area levels. A key element of the consortium's work is the construction of an extensive test bed linking the consortium members and demonstrating the feasibility of the design concepts. The current research in this area is focused on extending the channel speeds of the current wavelength division multiplexing implementation to 10 Gbps, on constructing a soliton based TDM local area network, and on developing the architecture for the wide area level. Professors Gallager, Humblet, Dr. Finn, and a number of graduate students are involved in this research.

**Wireless Communication**

During the past year, Professors Gallager and Trott, together with several students, have extended their research in wireless, mobile communication. Competing proposed techniques for wireless communication are currently evaluated by operational tests and by simulation, but the field lacks an adequate fundamental structure for evaluating the underlying merits of different approaches. The goal of our work is to develop a cohesive theory and set of insights for modern wireless communication. The current emphasis is on overcoming multipath channel effects, and on developing new approaches for multiaccess coding and decoding, power control, and adaptive antennas. Planned new topics are routing and congestion control in multihop wireless systems.

**Multi-Resolution Statistical Signal Processing**

For some time now there has been considerable interest in algorithms for the processing of signals or images at multiple resolutions. In the recent past, a theory involving the so-called "wavelet transform" has been developed for the deterministic representation of signals at multiple resolutions, and this has sparked a considerable response from the research community in exploring potential applications in a variety of areas ranging from computer vision to the fusion of multispectral measurements. An essential element in the development of a systematic methodology for the design of multiscale algorithms is the development of a statistical theory for multi-resolution signals. Continuing efforts to develop and apply such a theory are underway by Prof. Alan Willsky and Dr. William Karl together with their students and a group of researchers in Rennes, France. The initial results that have been obtained, together with the considerable attention this topic is receiving from the research community lead us to believe that this will be an extremely fruitful area for some years to come.

**Three-Dimensional Structure Determination**

Problems of three-dimensional chemical structure determination provide several test-bed problems for three-dimensional random field estimation which are simultaneously of great intrinsic importance. Solution of these problems is crucial to the understanding of natural biological molecules and for the engineering of novel new modified molecules--catalysts for industrial processes, drugs, and so forth. Furthermore, this is currently a field of intense interest in chemistry and biology with many eager collaborators within MIT. Finally, the understanding developed by studying these three-dimensional problems will transfer to other three-dimensional problems such as signal processing for sequences of images and atmospheric/oceanographic/seismic sensing with detailed, and therefore, three-dimensional, models. To address these problems, a research program involving Professor Sanjoy Mitter and Professor Alan Willsky is ongoing.

**Data Communication Networks**

Research in Communication Science and Systems ranges from basic information theoretical studies of networks and communication channels to the architectural design of network protocols. The major objective of this work is to develop the scientific base needed to design data communication networks that are efficient, robust, and architecturally clean. Both wide area and local area networks, both high speed and low speed networks, and both point to point and broadcast communication channels are of concern. Some of the topics in this area are multiaccess communication processes, routing, congestion control, diverse traffic mixes, the communication complexity and delay of distributed algorithms, failure recovery, and topological design. Professors Dimitri Bertsekas, Robert Gallager, and Pierre Humblet are conducting this research.

**Estimation, Statistical Signal Processing, and Inverse Problems**

A variety of stochastic estimation, analysis and signal processing problems are being studied by Professors Sanjoy Mitter, George Verghese, Alan Willsky, William Karl and their students. Theoretical studies are conducted in the areas of estimation algorithms for
Spatially distributed random processes, nonlinear filtering, relationships among filtering problems in scattering theory, and the analysis of large-scale systems subject to a variety of very rare events. Complementing this theoretical research are more applied projects, including the design of algorithms for detecting and compensating for sensor or actuator failures, and the development of model-based signal processing algorithms. The specific signal processing problems include the detection and identification of objects observed in synthetic aperture radar and laser radar imaging systems, the processing and assimilation of extremely large oceanographic data sets, the analysis and inversion of spatially-distributed geophysical data, the fusion of multimodal data sets, image processing and understanding, and computational vision.

Discrete-Event Dynamic Systems
During the past few years there has been considerable interest in the development of control concepts and algorithms for complex processes that are characterized more by the occurrence of discrete events than by differential equations representing the laws of physics. Such processes are typically man-made--flexible manufacturing systems, computer networks, etc.--and are often best described in symbolic, rather than numeric form. Professor Willsky's research is aimed at combining concepts from computer science and from control in order to develop a meaningful theory of control of such systems. In particular, the models and formalisms used in such a study come from the field of computer science (automata, synchronous processes, etc.), while the problems and design paradigms come from control (stability, regulation, robustness,...). The results to be obtained from this study should be of value in such diverse applications as distributed database management and flexible manufacturing.

Multivariable Robust and Adaptive Control
Systematic design of multiple-input-multiple-output systems, using a unified time-domain and frequency-domain framework to meet accurate performance in the presence of plant and input uncertainty is an extremely active research area in the Laboratory. Various theoretical and applied studies are being carried out by Professors Michael Athans, Munther Dahleh, Sanjoy Mitter, Gunter Stein and their students. Theoretical research deals with issues of robustness, aggregation, and adaptive control. The aim of the research is to derive a computer-aided-design environment for design control systems which can address general performance objectives for various classes of uncertainty. Recent application-oriented studies include the control of large space structures, helicopters, submarine control systems, issues of integrated flight control, control of chemical processes and distillation columns and automotive control systems.

Deterministic and Stochastic Nonlinear Dynamical Systems
The theory of nonlinear systems, both deterministic and stochastic, has developed rapidly during the last ten years. There is increasing interest in deterministic nonlinear control and various problems of adaptive control which lead to problems of nonlinear control. In the context of stochastic dynamical systems, problems of the qualitative behavior of such systems under different time-scales are of great interest. Recent work on nonlinear filtering has shown a relationship to infinite-dimensional, bilinear systems, and there is increasing interest in the understanding of qualitative behavior of nonlinear filters for large and small time-intervals. Finally, research is under way on the subject of control of discrete-event systems. Various investigations in this area are being conducted by Professors Michael Athans, Sanjoy Mitter, John Tsitsiklis, George Verghese, Alan Willsky and their students.

Theory and Algorithms for Optimization
This project focuses on analytical and computational methods for solving broad classes of optimization problems arising in engineering and operations research, as well as for applications in communication networks, control theory, power systems, computer-aided manufacturing and other areas. Currently, in addition to traditional subjects in nonlinear and dynamic programming, there is an emphasis on solution of large-scale problems involving network flows as well as in the application of decomposition methods. The thrust is twofold: first, to find ways to handle the typically huge number of constraints; second, to explore the use of distributed and parallel processing to reduce the computation time needed to solve a problem and to economize on information transfer from remote data collection points to a computation center. This gives rise to fundamental issues involving the synchronization of computation and communication that are as of yet only partially resolved. Professors Dimitri Bertsekas and John Tsitsiklis and their students perform this work.

Information Transfer and Retrieval
Research on information transfer retrieval focuses on making interaction with computer based information systems easier and more effective for human users. This research is supervised by Mr. Richard S. Marcus. A current project involves the development and testing of an expert computer retrieval assistant that should help make searching a quantified science rather than an informal art through proper structuring of, and operations on, verbal descriptions of database objects. These objectives are to be obtained through such (semi) automated techniques as (1) derivation of a conceptual formulation of a user's problem and its translation into an initial search strategy; (2) ranking by estimated relevance of documents retrieved thereby; and (3) analysis of user relevance feedback to (a) estimate the number of relevant documents not yet retrieved and (b) reformulate the search strategy to retrieve those missing nuggets. Experiments with a precursor to the expert system have already demonstrated retrieval effectiveness, in terms of numbers of relevant documents found, equivalent to that achievable by human information specialist acting as a search assistant. Partly based on this research, a series of operational and retrieval assistant systems have been developed.

System, Reliability and Risk Management
Research on risk assessment and management is carried out in many MIT departments and laboratories. At LIDS there is interest in describing the reliability of complex systems in terms of what is known about the reliability of their components. Professor Alvin Drake has supervised research on the development of models and algorithms for studying the manner in which uncertainties about component reliabilities are reflected in uncertainty about system reliability. The primary area of application has been to low probability, high consequence risks in nuclear reactor safety. Professor Drake is also concerned with probability assessment, particularly the quantification of expert judgment. A current project is detailed probabilistic analysis of the sequence of tests used to screen donated blood for the presence of AIDS-associated antibodies.
Center for Intelligent Control Systems
The Center for Intelligent Control Systems (CICS) combines distinguished faculty from MIT, Harvard University and Brown University in interdisciplinary research on the foundations of intelligent machines and intelligent control systems. Established in October 1986, CICS is headed by Professor Sanjoy Mitter, Director; Professor Roger Brockett, Harvard University, Associate Director; and Professor Donald McClure, Brown University, Associate Director. The research activities of the Center are loosely grouped into five areas: Signal Processing, Image Analysis and Vision; Automatic Control; Mathematical Foundations of Machine Intelligence; Distributed Information and Control Systems; and, Algorithms and Architectures. A number of outstanding graduate students are appointed Graduate Fellows. The Center also hosts several senior visitors for varying lengths of time each year. Continuation funding has been received.

Speakers in the 1993/94 CICS Colloquium Series included: Thomas Kailath, Hitachi America Professor of Engineering, Stanford University and Professor A.P. Dempster, Department of Statistics, Harvard University.

VISITORS TO THE LABORATORY
Among the visitors this year were: Vivek Borkar, Professor of Electrical Engineering, Indian Institute of Science.

HIGHLIGHTS
Professor Alan Willsky gave the opening keynote address at the IEEE Image and Multidimensional Signal Processing Workshop, Cannes, France, September 1993.

Dr. Clem Karl has been asked to serve on the organizing committee for the upcoming Workshop on Wavelets in Medicine and Biology, part of the International Conference of the IEEE Engineering in Medicine and Biology Society.

Prof. Munther Dahleh received tenure. He gave a plenary lecture at the American Control Conference, Baltimore, MD, June 1994.

Professor Mitchell Trott was awarded the KDD Career Development Professorship in Communications and Technology for 1994-1996, and a University Partnerships in Research grant through Motorola Codex in cooperation with G. David Forney, Jr.

ROBERT G. GALLAGER
SANJOY K. MITTER
The Laboratory for Manufacturing and Productivity (LMP), an interdepartmental laboratory in the School of Engineering, was established in 1977 to conduct engineering research in manufacturing and to develop the fundamentals of manufacturing science. The primary research focus is on design, analysis, and control of manufacturing processes and systems. Our long-term goal is to reduce the inherent complexity of manufacturing and improve system performance through a combination of process innovation and development of new fundamental principles for manufacturing science. In this way we seek to both improve the understanding of present manufacturing technology and to generate new methods and machines that will potentially restructure the entire enterprise of manufacturing. This approach enables us to blend basic research with real-world industrial problems.

As an interdepartmental laboratory, the LMP reports to the Dean of the School of Engineering, Professor Joel Moses. Timothy Gutowski, Professor of Mechanical Engineering, serves as Director, Dr. Andre Sharon serves as Associate Director, and Ms. Sally Stiffler serves as Assistant Director for Administration.

Since it is virtually impossible to address issues in manufacturing without considering the needs of industry, it is crucial that close ties between the Laboratory and manufacturing companies be maintained. In fact, over 40 percent of the research conducted in the LMP is sponsored by industry. Many of the sponsoring companies participate in our industry consortia, which include the Composites and Polymer Processing Program, the Tribology Program, the Microcellular Plastics Program, the 3-D Printing Consortium, and the Droplet-Based Manufacturing Consortium. Further technology transfer is facilitated by the LMP Industrial Collegium, presently comprised of over 35 companies with a common interest in manufacturing. The collegium serves as an information channel between industry and the LMP.

**RESEARCH AREAS**

Research activities in the LMP encompass the following areas:

- Process Innovation and Development
- Flexible Automation and Process Control
- Precision Engineering
- Tribology
- System Design, Scheduling and Production Planning
- Design/manufacturing integration

**Process Innovation and Development**

A large portion of our research is aimed at alternative processes that add flexibility, process new materials, and improve the performance of manufacturing systems. Current projects in this area include novel methods of fabricating composites, polymer processing, spray forming of metal-matrix composites, microcellular plastics, and three dimensional printing of ceramics and metals.

**Flexible Automation and Process Control**

Flexible automation can greatly increase the cost-effectiveness of a process. It can facilitate product changes with minimal retooling and change-over time. It is our goal to extend the capabilities of flexible automation through novel hardware, software, and control strategies. Process consistency can be further increased through real-time process control. The evolution of the process is continuously monitored and the input parameters are adjusted to eliminate errors caused by unforeseen parameter variations and process disturbances. Current projects in this area include flexible automation of composites materials, robotics, real-time control of welding processes, rapid prototyping systems, and real-time control of metal forming processes.

**Precision Engineering**

Precision engineering is the study of ways to make machines and components more accurate without a substantial cost increase. In this definition, it must be remembered that speed, force, temperature, and many other parameters all act to decrease the accuracy of a machine. Thus by its very nature, precision engineering is a multi-disciplinary field. Ongoing projects include an atomic resolution system for increased data storage, development of a magnetically levitated positioning system, and the development of high-precision machine components (such as ceramic bearings, spindles, ball-screws, etc.) that will facilitate development of high-precision machines.
Tribology

Tribology is providing a better understanding of wear mechanisms, which in turn leads to a more predictable and reliable product. Ongoing projects at the Laboratory are exploring wear mechanisms in various applications, including magnetic recording media, electrical contacts, and piston-cylinder interaction in internal combustion engines.

System Design, Scheduling, and Production Planning

Manufacturing is almost always comprised of systems: groups of machines, material handling devices, storage areas, computers, and people. While machines in isolation are relatively well understood, the interactions that occur within systems are less well known. In studying System Design, models to predict the effects of design choices (such as the set of machines and the sizes of storage areas) on system performance are developed; and optimization methods are developed to make the best possible choices. In studying Scheduling and Production Planning for manufacturing systems, production is viewed as a control problem, in which decisions must be made rapidly in response to events (such as the failure of a neighboring machine). Current research includes the design and operation of semiconductor fabrication systems.

Design/Manufacturing Integration

This emerging area concerns itself with the integration of the various phases associated with turning a concept into a deliverable product. These phases include design, manufacturing, quality control, marketing, etc. Much research is needed to develop the formal methodologies and tools that will facilitate such integration. Current efforts in the Lab are focused on formalizing the design process, developing new methodologies for concurrent engineering, as well as providing tools such as expert systems to aid the designer.

NEW INITIATIVES

Precision Engineering

Our effort in Precision Engineering lead by Professors Alexander Slocum, David Trumper and Kamal Youcef-Toumi, has seen significant growth in the past year. We have initiated several new programs in this area.

STATE-OF-THE-ART CNC MACHINING LABORATORY

With the help of Professor Slocum, we have taken the first step in establishing a state-of-the-art CNC machining laboratory in the LMP by acquiring a Brown and Sharpe coordinate measurement machine (CMM) and a CNC water-jet cutter to complement our other CNC equipment. This equipment will be used for research aimed at advancing the current state of the machine tool industry, as well as for educational purposes. Towards this goal, Professor Alexander Slocum has also received a grant from the NSF Infrastructure Initiative to acquire/develop a high-speed, high-precision Octahedral Hexapod machining center.

ANALYSIS AND DESIGN OF A VISCOSLY-DAMPED MAGNETIC SUSPENSION SYSTEM

Professor David Trumper has received a grant from the NSF to develop a precision magnetically-suspended six-degrees-of-freedom motion control stage capable of 1 angstrom resolution in a 100μm cube workspace.

DESIGN AND CONTROL OF A NANO-PRECISION PROFILOMETER

Professor Kamal Youcef-Toumi has received a grant from the Gillette company to develop a nano-scale inspection device to be used in manufacturing applications.

DEVELOPMENT OF A PROTOTYPE, LARGE AREA COVERAGE, MAGNETICALLY LEVITATED POSITIONER FOR LITHOGRAPHY

Professor David Trumper was awarded a grant from Sandia National Laboratory to develop and test an ultra precision, magnetically levitated positioning device to be used in lithography.

Droplet-Based Manufacturing

The Droplet-Based Manufacturing Consortium has grown to 5 members in the past year. Professor Jung-Hoon Chun, director of this consortium, has also received a grant from the NSF to study the process-structure relationships in droplet-based manufacturing, and a grant from the Aeroquip Corporation to develop a prototype mold fabrication technique for plastic injection molding.
Rapid Response Manufacturing

Professor Emanuel Sachs' program on Three-Dimensional Printing (a "tool-less" rapid prototyping and fabrication technique) continues to grow as he is awarded two large grants from ARPA:

LOW COST, HIGH PERFORMANCE TOOLING BY THREE-DIMENSIONAL PRINTING, AND STRUCTURAL MATERIALS OF THREE DIMENSIONAL PRINTING

In addition, Professor Sachs was awarded a new grant from the NSF to investigate the translation from electronic to physical models in design, using a rapid prototyping technique.

FLEXIBLE AUTOMATION FOR NEW PRODUCT INTRODUCTIONS

Professor David Hardt and Dr. Andre Sharon have begun a joint LMP/Manufacturing Institute Project funded by an industrial sponsor to develop new concepts for flexible mid-volume fabrication for the rapid introduction of new products to market. Such collaboration between the LMP and the Manufacturing Institute is expected to grow in the future.

OTHER DEVELOPMENTS

Professor David Hardt Steps Down as LMP Director

After 9 years of outstanding service to the Laboratory, Professor Hardt has stepped down as Director. He will continue to be an active member of the Laboratory through both research and teaching. All the members of the LMP would like to express their appreciation to Professor Hardt and wish him continued success in all his future endeavors.

Professor Timothy Gutowski Named Director of the LMP

Timothy G. Gutowski, Professor of Mechanical Engineering, was appointed Director of the LMP on January 15, 1994. Since joining the faculty in 1981, Professor Gutowski's research and teaching have been in the areas of manufacturing, mechanics and design, with an emphasis on advanced polymer composites. Professor Gutowski has directed the MIT-Industry Polymer Processing Program (later changed to Composites and Polymer Processing Program) since 1985. In 1986 he received an Alcoa Professorship, and in 1989 he was named an MIT Leaders for Manufacturing Professor.

Professor Gutowski received his B.S. in Mathematics from the University of Wisconsin in 1967, his M.S. in Theoretical and Applied Mechanics from the University of Illinois in 1968, and his Ph.D. in Mechanical Engineering from MIT in 1981. Prior to joining the MIT faculty, he taught engineering mechanics in South America, and spent five years at Bolt Beranek and Newman as a Senior Consultant. He is currently the North American Editor for the International Journal of Composites Manufacturing, and is on the editorial advisory board of the SAMPE Journal, the Journal of Thermoplastic composites, and the International Encyclopedia of Composites. Professor Gutowski is a recognized authority in the field of composites.

Professor David Trumper joins the LMP

David L. Trumper, Assistant Professor of Mechanical Engineering, has joined the LMP's Precision Engineering Group. Prof. Trumper's current research interests are in the areas of continuous- and discrete-time control, electromechanical systems, and magnetic suspensions and bearings for ultra precision motion.

Professor Trumper received his B.S., M.S. and Ph.D. in Electrical Engineering from MIT. Prior to joining the faculty at MIT, he worked for two years at Hewlett-Packard designing pressure control systems and two years at Waters Chromatography designing precision pumping systems for liquid chromatography. Professor Trumper also spent three years on the faculty of the Electrical Engineering Department at the University of North Carolina at Charlotte. His addition to the Laboratory will greatly strengthen our Precision Engineering Effort.

Professors Alex Slocum and Emanuel Sachs each win R&D 100 Awards

Two faculty members in the LMP have won the prestigious R & D 100 Award for the 100 most technologically significant new products of the year by R & D Magazine. The award was given to Professor Emanuel Sachs for his work on the 3-D Printing Process and Machine, and Professor Alex Slocum for his Replicated Internal Shear Damper.
Leaders for Manufacturing Program

INTRODUCTION
In 1993–94, two key transitions took place in the Leaders for Manufacturing (LFM) Program: (1) Stephen C. Graves, Professor of Management Science, succeeded LFM Management Co-director Thomas L. Magnanti, George Eastman Professor of Management Science. (2) Dr. Stephen A. Fairfield assumed full-time responsibilities as LFM Assistant Director for Operations, succeeding Marcia V. Chapman, Operations Manager.

Government funding through the Technology Reinvestment Program (TRP), effective 1 June 1994, will enable LFM to place up to three interns per year in small and medium-sized enterprises.

A progress report for the year on eight “products” designated by the LFM Operating Committee as essential to program success follows. Focuses were research, leadership development, and nationwide collaboration. The year’s highlights in these areas are asterisked below.

CONTINUOUS IMPROVEMENT
To document progress and improvement opportunities, the Leaders Program surveyed constituents this past year to issue a five-year report. To monitor significant data more frequently, LFM this year developed an operations report covering all aspects of the Leaders Program, with which to regularly update the Operating Committee and Governing Board.

COLLABORATION
The 13 industry partners during LFM’s first five years remain Leaders partners, maintaining and building on their close working relationship with MIT. In 1994, internships continued to increase the partners’ manufacturing competitiveness, sometimes dramatically. A partner company estimates, for example, that recommendations of one 1993–94 LFM internship will save it $82 million over a ten-year period.

The Leaders Program significantly changed its Governing Board meeting format this year to offer the governors more opportunity to provide direction for the program, interact with one another, and exchange ideas on major manufacturing issues. Meetings will now be hosted by the LFM governors themselves in a “round robin” of select partner facilities.

GRADUATES/CAREERS
The Leaders Program supported 86 fellows in 1993–94, bringing the total number of LFM fellows since the program’s inception to 257. Two students received Robert N. Noyce fellowships and three received fellowships from the National Science Foundation.

This past June, 46 LFM dual-degree fellows graduated. Of 43 fellows who had confirmed their plans in early June, 86 percent assumed positions in US manufacturing companies, choosing from an average of more than three job offers each. Most-cited reasons for job decisions had to do with growth potential, respect and recognition of recruits as individuals, and “good people fit.”

Leaders graduates (now 181) organized and hosted for the first time this spring an off-campus workshop (in Seattle) for all LFM alumni/ae; 47 graduates attended.

From 209 total applications received this past spring, 52 were accepted; 44 students (all with work experience) enrolled. The new fellows average 27 years in age and 4.3 years in work experience. Included in the new class are four women, two members of minority groups, and 11 partner-sponsored students.

Though women and minority group members are encouraged to apply to the LFM Fellows Program, their numbers in the program have declined in recent years. This situation is being studied and a strategy is under development to reach these individuals nationwide. They will be targeted in special LFM Admissions mailings this year, for example, and closer connections will be forged between the Leaders Program and professional organizations established for women and minority group members.

CURRICULA
*A distinctive feature of the LFM Fellows Program curriculum is its effort to further the understanding of leadership in manufacturing. The subject is developed primarily through skill development, practice (especially during the internship), and reflection, with limited classroom work. Second-year students prepare cases based on their internships to teach classmates and first-year fellows, helping first-years prepare for the internship while refining the cases as potential teaching materials for other MIT courses.
Leadership activities start with a unique orientation ("The Universe Within") to LFM during the fellows' first four days on campus in June. It offers a broad, multidimensional and nontraditional overview of leadership, ranging from behavioral scientific research findings to dialogue exploring systems concepts, "thought worlds" characterizing organizations, and communication, learning, and values. An underlying hypothesis is that fundamental organizational change requires reconsideration of core assumptions and objectives. The intent is to create among the fellows a learning organization that constructively challenges conventional mental models.

MANUFACTURING FACULTY
The Leaders Program actively involved 74 faculty and research staff in 1993–94. During this time period, four of the faculty were promoted, one of them gaining tenure.

*INTERDISCIPLINARY RESEARCH
Under direction of Drs. Eugene Meieran of Intel and Nils Muench of General Motors, more than 120 LFM industry partner and faculty researchers met this past year to define a collaborative research process. They identified nine programs as research imperatives that could significantly improve manufacturing performance. Most of the 46 short-term (internship) research projects and 36 long-term projects supported by the Leaders Program in 1993–94 are now categorized according to these nine research programs.

Criteria for selection of the research programs were importance to industry as well as faculty interest. Goals are to leverage research dollars, achieve synergies across diverse firms, facilitate collaborative research in “Big-M” Manufacturing, and obtain funding from external organizations.

Each research program consists of one or more technical groups led jointly by industry and MIT faculty, with representation from at least three LFM companies. The groups, which also offer "umbrellas" for both LFM interns and research assistants, are developing collaborative research projects.

To encourage more effective networking among many of the national organizations performing manufacturing research in the United States, Drs. Meieran and Muench and Dr. Douglas Braithwaite also compiled two directories: (1) Leaders for Manufacturing Research Program Contacts has been distributed to LFM partners involved in research; (2) A Manufacturing Science and Technology Research Database of university-based programs, government agencies, industrial consortia, national associations, and foundations actively involved in manufacturing research has been distributed to manufacturing engineers and managers in industry, universities, and government laboratories, agencies, and associations. In addition, LFM researchers now complete one-page “Research Sales Brochures” summarizing their work, categorizing it according to the nine research programs, and defining expected benefits.

The Leaders Program supported 36 graduate research assistants this past year, and the LFM Working Paper series now exceeds 400 titles.

IMPLEMENTATION AND LEADERSHIP
*The LFM co-directors participated in nearly 50 visits with government and university leaders this past year, broadening dialogue for university/industry/government partnerships to improve manufacturing. The University of Michigan, California Polytechnic State University, and Pennsylvania State University have joined MIT in developing a National Manufacturing/University Coalition to advance a national agenda of revitalizing US manufacturing.

The Leaders Program is also working with Worcester Polytechnic Institute (WPI) under a TRP grant to impact undergraduate education with LFM learnings.

THOMAS W. EAGAR
STEPHEN C. GRAVES
WILLIAM C. HANSON
INTRODUCTION
The Materials Processing Center (MPC) has positioned itself to respond to the changes in both the nature and scope of research in the United States. These changes are being driven by a dramatically altered defense agenda, a new national research policy, and a pragmatic corporate culture. The elimination of the strategic component of defense with the collapse of the Soviet Union and the perceived increase in international technology-based competition has led national policy makers to mandate "dual use" initiatives for the defense industries and national laboratories. This change in our federal government has also led to a national research policy shift away from "pre-competitiveness" and toward targeted industrial sectors. In addition, down-sized and restructured American companies have shifted their focus away from corporate-scale basic research and development toward operating division-scale product-focused priorities. These shifts are evident in the scope of the Department of Defense's Technology Reinvestment Program, with its emphasis on technology development and deployment of the existing knowledge base, and the dramatic growth of the Department of Commerce's Advanced Technology Program (ATP), with its emphasis on industrially derived research and development priorities. In both cases, the emphasis is on the commercial relevance of the proposed research as measured by active industrial participation and commitment.

In this new national research arena, the success of the university will depend critically upon its direct access to industry, industrial research, and technology planners. The MPC is well positioned to thrive within this industrially defined national research agenda. Our long tradition and active relationship with industry, through our domestic Industrial Advisory Board and international Industry Collegium, are proving to be an invaluable bridge between the materials research community at MIT and industry. Materials technologies are an important component of the federal agenda for science and technology, as important enabling technologies and as keys to system design for the automotive, electronic, construction, environmental, and aeronautical industrial sectors.

RESEARCH INITIATIVES
The MPC, as an interdepartmental center, provides an environment where industry, government, and academia can come together to collaborate in identifying and addressing pivotal multidisciplinary issues in materials processing and manufacturing. The MPC follows a three-pronged approach, involving programs in research, education, and industrial interaction, in its efforts to overcome traditional academic barriers and focus research and education on industrially relevant issues in the study and application of engineering materials. Our objective is to add significantly to both the academic and research funding base, with the emphasis on collaboration with other MIT centers and departments.

With our 40-member Industry Collegium, the MPC serves as the primary access route for industry to the MIT materials research community, as well as serving as the catalyst for actively promoting multi-investigator, multidisciplinary materials research initiatives. A key feature of each of the programs described below is the interdisciplinary interaction of faculty and research staff teams from various departments, including Chemical Engineering, Chemistry, Nuclear Engineering, Materials Science and Engineering, Mechanical Engineering, Electrical Engineering and Computer Science, and Aeronautics and Astronautics.

Our strategy is to build first upon teamwork among faculty, where each team represents a specific research program thrust. This structure optimizes broad cross-disciplinary faculty participation and provides focused areas of collaboration that are more responsive to industrial needs. Second, strategic partnerships with other MIT centers and departments, universities, national laboratories, and industry are established to avoid wasteful competition and to leverage our collective strengths. As an example, the MPC acts as the window to industry for the Center for Materials Science and Engineering (CMSE), creating associations vital to its National Science Foundation (NSF) support. In addition, the MPC focuses the use of its discretionary resources on cultivating and securing industrially sponsored research initiatives. The programs described below, many of which were initiated within the last year, reflect the activities of the MPC and illustrate key technologies identified by the MPC as important new areas of research thrust.

Materials Processing and Manufacturing Institute (MPMI): In partnership with the Department of Materials Science and Engineering, the MPC has sponsored the launch of this important research and academic initiative. This program facilitates MIT faculty, research staff, and student participation in high-priority industrial site projects, providing student interns with the combined benefits of an MIT academic experience and industrial research practice. It also breaks new ground in negotiating our direct participation in proprietary research projects at sponsor sites. Two students are currently on site through the MPMI, and discussions are ongoing with an expanding list of potential program sponsors.

Functionally Graded Structural Materials: Subra Suresh and Andreas Mortensen, both Professors of Materials Science and Engineering, and Hugh McManus, Professor of Aeronautics and Astronautics, have joined forces to launch a collaborative research initiative in functionally graded materials (FGMs) for structural applications. This spring the MPC and US Office of Naval Research (ONR) jointly sponsored an international symposium on FGMs. Functionally graded materials
are macromaterials that feature compositional or microstructural transitions engineered to deliver specific functional performance that varies with location within the sample. This team provides a synergistic opportunity to combine materials processing and micromechanics with structural component design. A research white paper has been invited by the ONR, and several companies have expressed interest in joining MIT in this initiative.

**Interfaces Working Group:** This working group was initiated with Yet-Ming Chiang, Harry Tuller, and Bernhardt Wuensch, all Professors of Materials Science and Engineering; John Vander Sande, Professor of Materials Science and Engineering and Associate Dean of Engineering.; and Jackie Ying, Professor of Chemical Engineering, who collectively represent one of the NSF-funded CMSE thrust groups. The working group includes 13 company and three national lab representatives. The objective of the MIT team is to make the results of their NSF-funded basic research directly available to interested industrial and national lab researchers and engineers, and simultaneously leverage this scientific knowledge base into focused research and development efforts with these same parties. Two focused workshops sponsored by the MPC for the Interfaces Working Group have resulted in industrial site discussions, several of which required the execution of new pre-proposal confidentiality agreements. Research and development agreements are currently being discussed.

**High Temperature and High Power Electronic and Optical Systems:** Initial exploratory discussions between Dr. John Haggerty, Senior Research Scientist with the MPC, and Dr. William Robbins of Draper Laboratory have led to the filing of four unfunded invention disclosures, the last of which includes Dr. Allen Murphy and Dr. Dennis Rathman of Lincoln Laboratory, in the area of high temperature and power electronic and optical systems. These components represent systems that are to be used in applications where power density, operating speed, and the operating environment require sustained and reliable performance at temperatures ranging from 120°C to 700°C. Draper Labs has committed IR&D funds as of July in support of this technology. It has also entered into discussions with the MPC to establish an MIT-Draper Labs joint venture to collaboratively develop broad consortium and independent third party research sponsorship of this technology. Lincoln Laboratory is also discussing the possibility of committing funds to the collaborative effort and is actively engaged in supporting our solicitation of both federal and industrial support. Several companies have expressed significant interest and are being pursued aggressively.

**Solid Oxide Fuel Cells:** During this past year, Prof. Harry Tuller has conducted a major proof-of-concept research project involving a class of solid oxide electrolyte materials that may significantly enhance the performance of fuel cells. The MPC recruited the active support of Dow Chemical and the collaboration of IBM, and this initiative has demonstrated sufficient results to warrant expanded funding from federal sources.

**Nanomaterials:** Kirk Kolenbrander, Professor of Materials Science and Engineering, has established a research program to develop a process for the production of nanosize semiconductor particles to be incorporated into a matrix material to form non-linear optically active materials and electronic devices. During the past year, a collaborative research effort has been established with Lockheed, which also served to provide the industrial matching funds for Prof. Kolenbrander’s National Young Investigator Award. The results to date are sufficiently encouraging to warrant a joint effort with Lockheed to secure expanded federal support.

**The Steel Industry and Industrial Ecology:** In cooperation with the steel industry, the American Iron and Steel Institute Waste Recycle Technology Task Force, and lead government agencies, the MPC sponsored a closed workshop at MIT in the Fall of 1993 to focus current efforts and establish short- and long-term research priorities in several areas of mutual interest, ranging from a rational basis for risk assessment to next generation steelmaking technology. This initiative was developed collaboratively with MIT’s PEEER program and was chaired by Donald Sadoway and Julian Szekely, both Professors of Materials Science and Engineering. Efforts are currently underway to establish collaborative research efforts.

**COLLABORATION WITH INDUSTRY**

Both the academic and research agendas of the MPC are critically dependent upon direct access to and interaction with industry. However, the MPC firmly believes that, due to the pace of technological innovation and the increasing federal and industrial emphasis on the relevance of research, new methods of knowledge and technology transfer are required that go beyond traditional publications and student graduation. To accomplish this, the MPC has de-emphasized its use of broad symposia in favor of focused workshops, academic and industrial working groups, and research joint ventures.

The **focused workshop** model was used to launch our functionally graded materials initiative. A select group of industrial and national lab representatives were assembled to discuss and plan the future for domestic FGM research with ONR representatives. Collectively, we planned an international focused workshop at MIT, which we organized and co-sponsored with ONR. The participants established the priorities for domestic FGM research and identified for us those domestic companies serious about FGM research, development, and use. The workshop has also led to the submission of a solicited white paper to ONR.

Our **interfaces working group** was also launched with a select group of industrial research and development directors associated with our Industry Collegium. This group confirmed for us the value of establishing an expanded working group of
industrial and national lab representatives with the combined goals of facilitating the transfer of new interface science research results and leveraging this knowledge base into collaborative and relevant industrial research and development projects. This Interfaces Working Group is the first of three such working groups launched in cooperation with the CMSE.

The MPC is negotiating its first research joint venture with Draper Laboratory and Lincoln Labs, based on jointly invented background intellectual property. The objective is to develop collectively a strategy that simultaneously optimizes generic consortium-based research on campus and proprietary or classified research at Draper and Lincoln Labs. Our goal is to exploit opportunities for parallel generic research and commercial development, thereby reducing the concept-to-product timeline.

In today’s internationally competitive environment, companies are increasingly sensitive to protecting their proprietary technologies while simultaneously requiring that our research become more relevant to their commercial needs. In order to facilitate more open dialogue and discussion around these conflicting points, the MPC has worked with MIT’s Office of Sponsored Programs to develop a standard pre-proposal non-disclosure agreement. This instrument has been very well received by our industrial clients and is quickly becoming an indispensable component of our expanded relationships.

While the majority of MPC’s past industrial research projects have been with larger companies, the new federally sponsored Small Business Technology Transfer Program (STTR) represents an excellent opportunity to collaborate with small companies. One STTR project has been funded with Lionel Kimerling, Professor of Materials Science and Engineering and MPC Director, and Implant Science Corporation in the area of silicon optoelectronic materials. Other STTR proposals are pending. In addition, the MPC will co-host a discussion and tour of the MPC for members of the local materials societies in January 1995. Our goal is to use this opportunity to establish closer ties with both large and smaller local materials companies.

In addition, the MPC is currently working with the Industrial Liaison Program to develop plans for a major international symposium for this coming year in materials. The focus will be on the new modes of interaction and collaboration the MPC has developed with industry and other research establishments. This will include presentations on the MPMI initiative and associated projects, our joint venture with Draper and Lincoln, the Dow-IBM solid oxide fuel cell program, the CMSE working group concept, and others. The goal is to illustrate the range of modes of direct interaction and collaboration fostered by the MPC by presenting existing successful programs. The purpose is to invite all of our most valued corporate clients to participate and then explore with each how we could further expand our relationship.

ACADEMIC INITIATIVES
In addition to the MPMI initiative discussed earlier, the MPC Summer Scholar Program, which is currently in its 11th year, has evolved into the MPC+CMSE Summer Research Internship Program. This is jointly funded by the MPC Industry Collegium and CMSE via its NSF Research Experiences for Undergraduates Program. This year’s group includes seven students, five from other universities and two from MIT. The program’s goal continues to be to attract a multidisciplinary array of students to graduate study in materials at MIT. In fact, four out of five students from our summer class of 1992 were admitted to MIT this year. In addition, we recruited industrial cooperative work-study positions for our affiliated departments at both the undergraduate and graduate levels.

ALLOCATION OF RESOURCES
The MPC has not been immune to the financial impact of the shifting defense and industrial research agendas. However, we expect to improve our research support base over the coming academic year, based on the strength of the industrial ties provided by our Industry Collegium, which is also recovering, as measured by an improvement in paid memberships. As we expand our services, we anticipate a squeeze on staff resources until a new plateau in support is achieved.

AFFIRMATIVE ACTION
The MPC has no faculty on its rank list. In our hiring of staff we make every effort to locate qualified minorities or women, in full compliance with MIT's affirmative action policies.

CONCLUSIONS
As we enter the post-cold war defense era with its correspondingly restructured and down-sized corporate culture, we can confidently report that the Materials Processing Center remains strong and is exploiting its access to industry to expand both MIT’s academic and research base. Our outstanding debt has been stabilized and we expect to retire it within two years. In addition, we anticipate increasing our industrial research sponsorship. The groundwork the MPC has already laid through its direct relationships with industry will result in expanded research collaboration and support.

Lionel C. Kimerling
INTRODUCTION
As a focus of study in several engineering disciplines, biomedical engineering continues to capture the interest of an increasing number of undergraduate and graduate students in the School of Engineering at MIT. This is evidenced in the record high number of undergraduate engineering students who have declared themselves to be pre-medical students and in the record high number of applicants for graduate study in biomedical engineering. Simultaneously, the number of engineering faculty whose research and teaching interests lie within the domain of biomedical engineering has also increased. This growth in biomedical engineering at MIT reflects the expansion in the health care and biomedical technology industry at the national level. In response, the MIT School of Engineering has created the Program in Biomedical Engineering.

MISSION
The mission of the Program in Biomedical Engineering is to develop educational opportunities in biomedical engineering for undergraduate and graduate students in the School of Engineering and to provide a vehicle for faculty in the School of Engineering to develop new multi-disciplinary research initiatives in this rapidly expanding field. An underlying objective for the Program is to unify diverse interests in biomedical engineering amongst the MIT faculty.

UNDERGRADUATE EDUCATION
Through the efforts of a large number of faculty this past year, the Program has created an Undergraduate Minor in Biomedical Engineering for students in the School of Engineering and the School of Science. This minor makes use of the availability of unrestricted elective time in established degree programs to provide undergraduates with a coherent minor program of study in biomedical engineering. For undergraduates in engineering and the physical sciences, the program stresses core subjects in biology and chemistry coupled with integrative studies in physiology and biomedical engineering applications. Because of the breadth of biomedical engineering and the diversity of its applications, it is necessary for the students in this program to enroll in more subjects than are normally required for a minor field of study at MIT. For this reason, and the fact that it is the first interdepartmental minor at MIT, the proposed program is being examined in detail by various faculty committees. This process should be completed by the end of the fall term, 1994.

BIOMEDICAL ENGINEERING INSTITUTE
Given its current rate of growth, it is anticipated that in economic terms, the health care industry in the year 2000 will amount to $1.6 trillion or 16 percent of the Gross Domestic Product (GDP). While there is no particular amount that could be universally agreed upon as the "right" amount, it is noteworthy that national expenditures for health care in most developed nations are consistently about half the U.S. amount when measured against GDP. Although there is a widely held view that technology is a major factor in the escalation of health care costs, it is the view of a group of biomedical engineering faculty at MIT that the judicious application of technology can actually reduce the costs of health care.

Accordingly, the Program in Biomedical Engineering is presently working to establish the Biomedical Engineering Institute as a partnership that brings together experts from academia, industry, and the health care sector for the specific purpose of developing and testing new proprietary technologies that will reduce the cost of health care while simultaneously improving its quality, efficacy, and accessibility.

While the objectives of this Institute are manifold, they can be grouped into three broad categories: (1) to serve as an engineering resource to hospitals and the biomedical technology; (2) to research and develop new cost-saving technologies for patient care; and (3) to provide special educational opportunities to MIT biomedical engineering students and faculty as they participate in the development process. Efforts are currently underway to enlist the participation of hospitals and industrial firms in this new enterprise.

SYMPOSIUM ON HEALTH CARE TECHNOLOGY IN THE 21ST CENTURY
For the coming academic year, the Program in Biomedical Engineering is planning a major symposium to examine the economic and technological challenges of the health care industry in the 21st century. This symposium, which will be co-sponsored by the PBE and the Office for Corporate Relations, will bring together leaders from the health care industry, the biomedical technology industry, government, and academia for the purpose of identifying opportunities for technological innovation to reduce the cost of health care while at the same time improving its efficacy and accessibility. Participants in this two-day program will examine the needs and the constraints of the health care industry in the coming century and the ways in which technology can meet these needs within these constraints. The outcomes from the symposium will help set the research and development agenda for the aforementioned Biomedical Engineering Institute.

ROGER D. KAMM AND ERNEST G. CRAVALHO
The Program for Environmental Engineering Education and Research (PEEER) is now approximately two years old. PEEER functions as a virtual center with the mission of coordinating and focusing research and education on the intersection between technology and a sustainable development. Centered mainly in the School of Engineering, PEEER involves faculty and research staff members and students from all of the other schools at MIT in examining a wide range of technology-related environmental problems. The objective of the program is to establish multi-disciplinary research efforts where none now exist and to strengthen existing efforts. The MIT units most active in PEEER activities are:

- MIT Energy Laboratory
  Professor Jefferson Tester, Chemical Engineering
- Center for Technology, Policy and Industrial Development (CTPID)
  Professor Daniel Roos, Department of Civil and Environmental Engineering
- Program in Business, Technology and the Environment
  Dr. John Ehrenfeld, Senior Lecturer in Chemical Engineering and Senior Research Engineer, CTPID
- Center for Environmental Health Sciences
  Professor William Thilly, Division of Toxicology, Department of Civil and Environmental Engineering
- MIT/EPA Center for Airborne Toxins
  Professor Adel Sarofim, Chemical Engineering
- MIT/EPA Center for Environmental Remediation
  Professor Dennis McLaughlin
- Materials Systems Laboratory
  Professor Joel Clark, Materials Science and Engineering
- Ralph M. Parsons Laboratory of the Department of Civil and Environmental Engineering
  Professor Harold Hemond, Department of Civil and Environmental Engineering
- Department of Urban Studies and Planning
  Professor Larry Susskind and Professor Lawrence Bacow
- Department of Aeronautics and Astronautics
  Professor Ian Waitz
- Department of Nuclear Engineering
  Professor Scott Simonson
- Department of Chemical Engineering
  Professor Gregory McRae
- Department of Materials Science and Engineering
  Professor Donald Sadoway

**Evolving Areas of Research in Environmental Engineering**

This year’s efforts have been focused on building a strong long-term research base consistent with PEEER’s research agenda. The program has pursued work in the four areas of:

- Industrial ecology, life cycle analysis, clean technology, green design, and waste minimization;
- Defining, measuring, monitoring, and modeling impacts of pollutants on environmental sustainability;
- Waste management and environmental remediation; and
- Incorporating the best possible science and technology into environmental decision making.

Considerable research in traditional disciplines is underway at MIT in the area of environmental sciences, technology, and engineering. Several examples show the scope of this work: The Parsons Laboratory, part of the Department of Civil and Environmental Engineering, has a research program of almost $4.5 million per year devoted to the study of the impacts of pollutants in the natural environment, including work in aquatic sciences, hydrology, ground and surface water quality modeling, and environmental remediation. The Department of Chemical Engineering has an ongoing commitment to the study of the impacts of incineration and combustion, a program which the department is now extending to air pollution modeling. Its Masters Level Practice School Program is almost totally devoted to pollution prevention activities at industrial sites. The Department of Mechanical Engineering, through the Sloan Automotive Lab, is exploring new aspects of the impacts of automotive engineering on the environment. The MIT Energy Laboratory has worked for almost 20 years on problems of energy and the environment. The Department of Earth Atmospheric and Planetary Sciences, along with the Department of Civil and Environmental Engineering, through the Center for Global Change Sciences, are making strong commitments to modeling the impact of natural and man-made changes in the global climate.
This report focuses on a set of activities that represent a new phase of environmental study at MIT. It demonstrates PEEER's role in stimulating and supporting new inter-disciplinary activities especially in areas of newly evolving research, such as industrial ecology and the influence of science and technology on environmental policy. These activities build on MIT's strong disciplinary base in fields fundamental to the understanding of environmental issues. They bring together groups of investigators studying differing aspects of an environmental problem to analyze it and contribute to appropriate solutions.

Examples of such work are:

**Pro-Active Environmental Strategies for Industry**
PEEER is supporting the formation of industrial consortiums seeking strategies to enable industrial groups to anticipate environmental concerns. Some of these strategies depend on the concept "industrial ecology," an analytical perspective regarding systems of materials extraction, processing, product design, manufacturing, recycling and use in a holistic manner. The main tool of industrial ecology is life cycle analysis, a framework including not only materials flows and waste emissions but also the internal and external incentives that guide them. Other approaches to the development of pro-active environmental strategies are focusing on how an industry might develop an approach that is right for it. Part of this effort involves developing structures for dialogue between industry, regulators, and public interest groups. During the past year the following initiatives have been organized:

**Managing the Future Uses of Chlorine**
This year, a new interdisciplinary "Chlorine Seminar" was organized to focus on issues revolving around the management of the future use of chlorine. Through the MIT Council on Global Environment chaired by Provost Mark Wrighton, major funding on the order of $1.6 million over three years has been obtained to support disciplinary research in the area of chlorine management. The semi-monthly Chlorine Seminar integrates the work being pursued through this grant, which includes nine full-time student fellowships and faculty support packages. Members of chlorine-producing and user industries, government regulators, and members of public interest groups concerned about the environmental impacts of chlorine have also been invited to address the seminar.

PEEER Director David H. Marks, James Mason Crafts Professor of Civil and Environmental Engineering, chairs the seminar. Participating faculty in 1993/1994 were Professors Gregory McRae (Chemical Engineering), Paul Barton (Chemical Engineering), Rick Danheiser (Chemistry), Vicki Norberg-Bohm (Urban Studies and Planning), Kenneth Oye (Political Science), Harold Hemond (Civil and Environmental Engineering), Mario Molina (Earth, Atmospheric and Planetary Sciences), Ronald Prinn (Earth, Atmospheric and Planetary Sciences), and Dr. John Ehrenfeld, Director of the Technology, Business and the Environment Program. The seminar will continue at least through the next academic year; additional faculty participants will include Professors Donald Sadoway (Materials Science and Engineering), Nazli Choucri (Political Science), and Gerald Wogan (Chemistry).

Planning and organization for a symposium on managing the future use of chlorine began in Spring 1994. The meeting will bring together representatives of the many constituencies affected by the use and regulation of chlorine. The objective of the meeting is two-fold: The first goal is to explore the roles of universities in building strategies for managing chlorine. The second is to move toward the formation of a academically based "chlorine network". The network will also serve as a model for an interdisciplinary, cross-sectoral approach to other issues of chemicals in the environment.

**The Technology, Business and the Environment Program (TBE)**
Dr. Ehrenfeld presented a major workshop November 3 and 4, 1993 which built on practitioners' experience with life cycle analysis. The conference attracted over 175 attendees and helped to document many of the barriers to defining, formalizing, and implementing life cycle analysis. The TBE program ran monthly seminars heavily attended by representatives of industry, environmental groups, and government during the year with a major emphasis on examples of corporate voluntary environmental stewardship.

**The Automobile and the Environment**
Automobiles interact with the environment in every phase of their production and use. A loose confederation of different actors are working at this interface. In the Materials Systems Laboratory, Professor Joel Clark is developing detailed cost models of materials substitutions in the auto industry and their impacts on environment, cost, fuel economy, and safety. Funding for this program comes in part from the International Motor Vehicle Program (IMVP) directed by Professor Daniel Roos and from the US Department of Energy through the MIT Energy Lab, with some industrial sponsors. The PEEER Initiative in Regional Air Pollution detailed below is also contributing to these activities. The Technology, Business and the Environment Program is investigating industrial responses to environmental pressures in conjunction with the IMVP. Investigators in the Departments of Chemical Engineering and Mechanical Engineering are studying the nature of combus-
tion. Research into the impacts of automobile traffic is being pursued in the Department of Civil and Environmental Engineering. Ongoing work in both these areas are being integrated into a systems approach to the study of the impact of automobiles on the environment.

**Environmental Strategies for the Electronics Industry**

Microelectronics and Computer Technology Corporation (MCC) and Semitech are combining to begin a large program on the “Greening of the Work Station” dealing with problems of recycling, material substitution, and health effects related to electronics and computer equipment. Rafael Reif, Professor of Electrical Engineering and Computer Science and Professor Sadoway are beginning work in the Micro Systems Technology Laboratory, a full-scale pilot chip production facility in Building 39. The work will address issues of pollution prevention, particularly the use and emission of toxic and hazardous chemicals in the manufacturing process.

**Environmentally Conscious Manufacturing and Design**

The Materials Systems Lab is collaborating with Sandia Labs to study environmentally conscious manufacturing and design. The Design Group in Mechanical Engineering is also beginning to build work in this area.

**Technology and Sustainable Development:**

A Model for MIT and a place for MIT Leadership

PEEEER faculty and affiliates continue to look for a way to describe and define the intersection between technology and sustainable development. Groups within the Parsons Laboratory, the Department of Civil and Environmental Engineering and the Technology and Policy Program are investigating the many ways in which human beings interact with and alter their environments. This research is leading toward a new discipline which might be termed “ecological engineering”. Its objective would be to identify and remediate impacts of past improper practices and to move towards a better, more sustainable relationship between natural processes and human activities. PEEER faculty are engaged in both aspects of the developing idea of ecological engineering: environmental remediation and environmental management.

**Environmental Remediation**

Dr. Elizabeth Drake of the MIT Energy Lab is leading a new interdisciplinary team to develop funding and cooperation to handle large quantities of mixed waste (radioactive and hazardous) at weapons sites and bases managed by the US Departments of Energy and of Defense. Funding for the 1993-94 phase of activities was provided by the Lee and Geraldine Martin Foundation; it is being used to build new environmental remediation technologies and tools. To assist in this effort, the E-Lab is drawing on expertise in the Parsons Laboratory, the Departments of Civil and Environmental Engineering, of Nuclear Engineering, and of Mechanical Engineering, and the Plasma Fusion Laboratory (Physics) to find ways to neutralize or dispose of hazardous and toxic wastes currently threatening the environment. Under the leadership of Professor Marks, MIT faculty members have begun a long-term project to direct the development of education and new technologies for environmental remediation at the Otis Air National Guard Base on Cape Cod, Massachusetts.

**Environmental Management**

As industry moves toward more ecologically-sound systems of production, distribution, and disposal of products, government must find ways of managing currently unavoidable environmental problems. Through a gift of funds from the Lee and Geraldine Martin Foundation, PEEER has been able to initiate a new project to develop strategies to implement the 1990 Clean Air Act Amendments in the northeast United States. This project, under the leadership of Professor McRae, has brought together faculty members from the Departments of Architecture, Chemical Engineering, Materials Science and Engineering, Civil and Environmental Engineering, Urban Planning, and Earth, Atmospheric and Planetary Sciences in a major modeling initiative. A conference in July 1993 with the governmental groups responsible for these activities helped define strategies for data gathering and policy formation.

**EDUCATION**

MIT does an excellent job of educating and advancing the knowledge base for those who see themselves as environmental professionals (in areas like Civil Engineering, Chemical Engineering, Earth, Atmospheric and Planetary Sciences, and Urban Studies and Planning). Examples are the new Course I-E in Civil and Environmental Engineering which provides an undergraduate education opportunity for work in Environmental Engineering Sciences. While students are flocking to these areas they represent at most less than ten percent of MIT's undergraduates and less than five percent of graduate students. The next task is to educate the much larger group of engineering, science, management, and social science students whose daily professional decisions about materials choice, processing, product design, development strategies and recycling will have substantial implications for the environment. PEEER is working to amplify the environmental educations of majors and non-majors in the field.
Chemicals in the Environment

PEEER has created a four-subject graduate sequence in Chemicals in the Environment which is designed to give graduate and advanced undergraduate students the skills they will need to become effective managers of the environment. The subjects have been developed to provide a systematic and interdisciplinary look at the critical issues of chemicals introduced into the environment and the workplace. These subjects, designed for non-majors, are:

- Chemicals in the Environment: Sources and Controls (Chemical Engineering)
- Chemicals in the Environment: Chemicals and Human Disease (Toxicology)
- Chemicals in the Environment: Environmental Fate and Transport (Civil and Environmental Engineering)

This series received the 1991 MIT Sizer Award for outstanding contribution to education at MIT.

The AT&T Industrial Ecology Curriculum Development Grant

In a competition in 1993, the AT&T Foundation awarded grants to six academic institutions for work in advancing the emerging field of industrial ecology. This perspective enables analysts to find ways to eliminate or minimize environmental impacts at every stage of a product's life cycle, from design to manufacture to use and disposal. The field, which deals with the integration of technology and environment in all economic activity, includes elements of engineering, physical science, economics, management, and law. The group of faculty members at MIT has been involved for some time in research and educational development in the area of industrial ecology.

In funding this project, AT&T has named Professor Marks, Professor Sadoway, Dr. Ehrenfeld, Professor Clark and Professor de Neufville as AT&T Industrial Ecology Fellows. The proposal for the project outlined a major educational initiative designed to interject environmental options into masters-level engineering education at MIT. Through design, development, testing, and implementation of such materials at MIT, the project proponents hope to influence similar advances in other institutions as well. The immediate goal of this work is to establish the foundations of a masters-level professional degree in industrial ecology at MIT. This year, substantial progress has been made in putting together a module of industrial ecology subjects. The Department of Materials Science and Engineering has agreed to make it a degree option in their new professional masters degree, as described below. The industrial ecology project group is working toward integration of this module in other degree programs as a whole or as individual subjects.

Professional Masters Degree in Materials Science and Engineering with the Industrial Ecology Option

Unlike the more traditional masters degree programs which prepare students for careers in research, the proposed program focuses on industrial practice and is designed to appeal to students who are interested in environmental issues. Central to the effort is the development of so-called core integrating subjects in industrial ecology which introduce concepts of the field and reinforce them with case-study examples from industry. These integrating subjects also emphasize working in teams, solving complex problems, developing communication skills, and promoting interaction with other disciplines and with professionals from industry and government. In short, it is our intention to provide our students with the analytical tools, knowledge, and global understanding to enable them to become future leaders in a world moving towards sustainable development.

The new degree with the Industrial Ecology Option consists of three curricular blocks:

- **Block One:** Core Professional Subjects from DMSE
- **Block Two:** Core Subjects in Environmental Management using subjects from PEEER’s series, “Chemicals in the Environment”
- **Block Three:** Integrating Subjects in Industrial Ecology
- **Block Four:** Internship and thesis in industry.

Block Three consists of the core integrating subjects in industrial ecology which introduce concepts of the field and reinforce them with case study examples from industry. Three such term subjects and an IAP short course are presently under development, work in large measure supported by the AT&T Foundation grant. The proposed subjects are: 3.xx Materials and the Environment, a new subject in industrial ecology being developed by Professor Sadoway; TPP 123 Industrial Ecology of the Automobile, taught in Spring 1994 by Professor Clark, Dr. Frank Field and Professor de Neufville; and 1.141J, 3.563J Strategic Analysis For Environmental Planning And Design, taught by Professors Michael Golay, Clark, de Neufville, Marks and Dr. Field.
A related subject focusing entirely on the improvement of air quality in the Los Angeles basin and including issues of hybrid vehicles, electrical vehicles, fuel choice, and a variety of other demand management alternatives was developed and taught in Spring 1994.

Leaders for Manufacturing: Environmental Education
In IAP, 1994, Professor Marks and Dr. Ehrenfeld ran an Environmental Boot Camp for students in the Leaders for Manufacturing Program (LFM). The three-day subject covered environmental issues that confront those working in industry and the regulatory context for environmental management. It addressed questions most often asked by former LFM graduates. Subsequently, Dr. Ehrenfeld has developed and led an initiative in product life-cycle concerns for the Leaders for Manufacturing Program. Dr. Ehrenfeld and Professor Marks will serve as advisors for a new group of environment-oriented LFM students starting in Fall 1994.

Environmental Literacy Subjects at the Undergraduate and Graduate Levels
Professor Philip Gschwend (Civil and Environmental Engineering) and Dr. Ehrenfeld taught a new undergraduate subject 1.01J, 10.271J Environment and Technology in the fall term of 1993. It grew out of a successful IAP 1992 short course of the same name which attracted about 30 non-environmental majors in its first offering. With PEEER backing, Professor Ian Waitz taught a new subject in Aeronautics and Astronautics 16.542 Environmental Aerospace Engineering in Spring 1994. Professor Marks teaches a subject in Environmental Remediation Engineering in conjunction with a local consulting firm in which project teams develop solutions to real industrial problems.

Modules on Environmental Concerns
Course modules emphasizing environmental concerns have been introduced into regular professional design subjects in the Departments of Chemical Engineering, Civil and Environmental Engineering, Aeronautics and Astronautics, and Ocean Engineering.

Continued Evolution of Degree Programs
At the undergraduate and graduate level, degree programs in Environmental Engineering Science (Civil and Environmental Engineering) continue to grow and expand. The Technology, Management and Policy Program, an interdisciplinary standing doctoral committee recognized by the Dean of the Graduate School, now enables doctoral students to compose a significant minor or major in pollution prevention/industrial ecology/clean technologies areas, which has not been institutionally feasible in the past. The Department of Civil and Environmental Engineering has established a professional Masters of Engineering degree program with an option in environmental engineering. The Department of Ocean Engineering has also established an master's program with an ocean environmental systems focus.

Undergraduate Minors in Environmental Studies
Two minor programs are being made available: the minor in environmental engineering, offered through the Department of Civil and Environmental Engineering, and an Institute minor in environmental studies overseen by the PEEER faculty. Each degree program specifies six sets of approved subjects that MIT will recognize as official environmental minors to be so recorded on transcripts and diplomas. Professor Gschwend is leading the Civil and Environmental Engineering program. Professor Judith Kildow of Ocean Engineering is organizing the Institute environmental studies minor.

OUTREACH
Several of the initiatives outlined above included outreach to the industries, and governmental agencies, and public interest groups involved in the issues taken up by PEEER. In order to improve problem definition, share research findings, and identify emerging issues of interest to MIT, the program is communicating with these sectors through meetings, invited speakers, and publications. Some of the larger meetings this year have included:

An Environmental Strategy for the Steel Industry
Professors Sadoway, Julian Szekely and Thomas Eagar of the Department of Materials Sciences and Engineering organized a meeting of representatives of the steel industry in November, 1993 at MIT to look at proactive environmental strategies. Senior technical and senior managers of major steel firms discussed new approaches, policies, and technologies. Professor Sadoway is developing new clean technologies for the production of steel and other heavy metals and has proposed methods for disposing of toxic wastes by using them as inputs to steel making.

Proactive Environmental Strategies for Industry
A major IILP Symposium on Proactive Environmental Strategies for Industry was presented at MIT on November 17, 1993.
It was attended by over 100 people and focused on the proactive steps that industry can take to get ahead of liability and compliance problems.

Center for Talented Youth (CTY)
MIT ran an environmental day for the CTY which brought 550 talented and specially selected seventh, eighth and ninth grade students to MIT on Saturday October 25, 1993. Professor Kildow of Ocean Engineering acted as MIT Coordinator of this event, in which many faculty members and graduate students acted as speakers and group leaders.

Publications
PEEER is responsible for the publication of Environment MIT and Environmental Calendar. Both are edited by Dr. Teresa Hill. The newsletter, Environment MIT, includes synopses of research, editorial comment by faculty members, announcements, and other news of environmental studies at MIT. Environmental Calendar appears monthly, and includes details of upcoming events. Special issues of both these publications appear when appropriate. For example, for the last two years, the September issue of Environment MIT has been devoted to describing the wide range of education and research programs in environmental studies available at the Institute. Each term, and for IAP, a special issue of Environmental Calendar directs readers to subject offerings of special interest.

DAVID H. MARKS
INTRODUCTION

The MIT Industrial Performance Center (IPC) is dedicated to the study of industries in the U.S. and in other advanced economies. It brings together the intellectual resources of the Institute in a search for fresh insights into the nature and origins of successful industrial performance, and it develops practical new approaches for strengthening public policies, business strategies, and engineering practices concerning these important issues. About 30 faculty and more than 50 students from 10 departments are participating in the center’s activities.

BACKGROUND AND GOALS

For the best part of two decades, the real incomes of much of the American workforce have stagnated. The single most important reason for this has been the weak productivity performance of the U.S. economy. Slow productivity growth remains a serious threat to the nation’s future prosperity.

The MIT Industrial Performance Center was established in the fall of 1991 with the assistance of a major grant from the Sloan Foundation. The mission of the center is to conduct research and to create new educational opportunities with the objective of understanding better and improving industrial performance in the United States and elsewhere. The center’s conception of industrial performance encompasses productivity, quality, flexibility, new product and process development capabilities, organizational innovations, human skills and mastery of productive processes, and command of strategic technologies. The center seeks to further the understanding of systems of industrial production through the search for new principles and the development of useful new techniques and models of performance.

Key institutional objectives of the Industrial Performance Center are to develop new working relationships with industry and government, to provide new forums for discussion of practical strategies and policies, and to help build a national community of scholars and practitioners concerned with problems of productivity and industrial performance.

RESEARCH PROGRAM

The IPC’s research program is organized in five broad areas: (1) Design and New Product Development, (2) Skills, Incomes, and the Organization of Work, (3) Capital Equipment Supply and Use, (4) National Technological and Industrial Policies and Practices, and (5) Regional Industrial Development. There are a total of 16 active research projects in these areas involving faculty and students from the Schools of Engineering, Management, Architecture and Planning, and Humanities and Social Sciences. These projects include the following:

Design and New Product Development

The Organization of Product Development. This research contrasts what is today the dominant conceptual approach to design and product development, an approach that is analytical and problem-oriented, with an alternative approach that is interpretative and process-oriented. The interpretative approach views product development as entering into an on-going process in which people are already engaged. It sees the interactions between the different communities involved in product development as a set of on-going conversations. It suggests for a set of conceptual tools for organizing design and product development activities that are quite distinct from those associated with the conventional, analytical approach. Studies of design and product development in a range of industries, including telecommunications, automobiles, financial services, apparel, and pharmaceuticals are being carried out.

Principal Investigators: Professor Richard Lester, Professor Michael Piore and Professor Fred Kofman

Skills, Incomes, and the Organization of Work

Technology and Changing Skill Requirements. This project is examining the impact of changes in technology and organization on the skill requirements for employees in a major area financial institution. Employment in this institution grew from 3000 to 10,000 over the past twelve years, and the organization has experienced far-reaching changes in both technology and the organization of the workplace.

Principal Investigators: Professor Frank Levy and Professor Richard Murnane
The International Outsourcing of Labor by American Multinationals in the 1980s. This research is exploring the extent to which American multinational corporations in the 1980s were outsourcing unskilled-labor-intensive activities to foreign subsidiaries and were thereby contributing to the demand shift away from unskilled labor and toward skilled labor that occurred in the majority of American industries in the 1980s.

IPC Doctoral Fellow: Mr. Matthew Slaughter

Technology, Work Reorganization and Productivity Growth in Telecommunications. The objective of this project is to develop a theory of high performance work systems in the service sector through studies of technological and organizational/human resource changes in two regional Bell operating companies, and to examine whether such systems produce higher productivity. The research is developing a deeper understanding of the methods and effects of restructuring at four levels: industry, firm, business unit and work unit.

IPC Doctoral Fellow: Ms. Rosemary Batt

Workplace Restructuring in the North American Steel Industry. Despite similar starting points and identical competitive challenges, North American steel firms have displayed considerable variation in the process and outcome of workplace restructuring. This research focuses on two specific questions. First, what explains the emergence of specific forms of work organization in response to the challenges of the new competitive environment? Second, what implications do these various forms of work organization have for firms, workers, and unions?

IPC Doctoral Fellow: Ms. Ann Frost

Organizational Innovation and Its Limits in the American Labor Movement. This research seeks to identify and analyze the underlying factors supporting organizational and strategic innovation in the American labor movement. Contrary to popular opinion, many unions have experimented with major changes which have allowed them to play a positive role in the restructuring of American industry. Analyzing which factors support this positive shift in certain unions as well as what other organizational or institutional factors hinder the diffusion of these new experiments is the key objective of this project.

Principal Investigator: Professor Richard Locke

Capital Equipment Supply and Use

Information Technology and Productivity. This project seeks to understand the relationship between information technology (IT) and productivity through a combination of field-based observation, measures of IT's impacts, and models of the principal phenomena. The goal is not only to diagnose the immediate causes of the 'productivity paradox', but in the longer run to enhance our understanding of information technology's impact on the organization of work, providing the basis for improved productivity and competitiveness.

Principal Investigator: Professor Erik Brynjolfsson

The Global Process Equipment Industries: Policy Analysis for Firms and Governments. This project has three components. The researchers are (1) studying the factors that influence the design and choice of processing equipment and factory architectures; (2) studying customer-supplier relationships and equipment sourcing policies, and how these affect competitive advantage through the use of proprietary process technology; and (3) trying to quantify the extent of positive externalities present in the process equipment industries, and to understand how different governments and firms in Europe, Asia, and North America have tried to internalize existing externalities in these industries and document the relative advantages of the different approaches. Initially, two types of process equipment are being studied: machine tools used by the automobile industry; and process equipment used for semiconductor manufacture. The methodology is primarily field-based, but guided by knowledge and conceptual foundations in the fields of operations management, economics, and engineering. Several company research partners have been identified. The researchers are coordinating their efforts with several of the Sloan Foundation's Industry Studies.

Principal Investigator: Professor Charles Fine

National Technical and Industrial Practices and Policies

Domestic Institutions, Free Trade and the Pressures for National Convergence: US, Europe, and Japan. The purpose of this research is to understand (1) the forces that are promoting/resisting convergence of national labor and capital market institutions; (2) the strengths and weaknesses of alternative industrial structures and patterns of behavior; (3) to what extent convergence ought to be promoted or resisted; (4) if convergence is desirable, who ought to converge towards whom? An international conference was held at Bellagio, Italy bringing together American, European and Japanese scholars and
practitioners. The role and limits of convergence of national industrial policies and domestic business practices in international industrial competition were examined. A manuscript for publication as a book is in progress.

Principal Investigators: Professor Suzanne Berger and Professor Ronald Dore

International Comparisons of Industrial Relations/Human Resource Practices. In this project, comparative research is being carried out in ten OECD countries on the impacts and implications of changes in industrial relations/human resource practices concerning work organization, compensation schemes, skill formation, corporate governance, and job mobility/security. The project team includes scholars from each of the ten countries and is led by the MIT participants. A two-phase project structure has been adopted, with phase I involving preparation of national papers designed to further refine and apply the analytical framework, and phase II involving more detailed cross-national studies of particular industries. The first phase has been completed, and a book will be published by the MIT Press. Work on phase II has begun, with workshops on autos, telecommunications and steel all held during the past year. A conference summarizing the results of the research for the Commission on the Future of Worker Management Relations and other interested government, business and labor representatives was held in March 1994. Partial funding for the project is being provided by the OECD.

Principal Investigators: Professor Michael Piore, Professor Thomas Kochan, and Professor Richard Locke

State-Building and the Transformation of the Governance of Industrial Innovation in the US, 1932-1950. The objective of this research is to understand the political foundations of the post-World War II US science and technology policy system in the Federal Government, particularly for policies that influence economic growth and competitiveness, to expand and refine the historiography of this policy area in the 1930s and the 1940s, and to integrate an explanation of events in this policy area into the larger understanding of American state-building during the period. The research will also extract lessons from this period for current policy-makers.

IPC Doctoral Fellow: Mr. David Hart

Regional Industrial Development

The Restructuring of Chicago's Small Firm Metalworking Industry: Vertical or Horizontal Production Networks? The purpose of this research is to study the metalworking firms in the Chicago area in order to determine how the pattern of local network production has evolved there from the 1920s to the 1990s and to explore the implications that this type of interfirm network may have had for the metal-related manufacturing complex in the Midwest as a whole. A key hypothesis: that horizontal relationships among metalworking suppliers have been weakened by the creation of vertical customer-supplier networks, and that this might seriously hamper innovation and information-sharing among an entire industrial complex.

IPC Doctoral Fellow: Ms. Lynn McCormick

Industrial Performance Indicator Database

Researchers at the Industrial Performance Center are assembling a comprehensive database of industrial performance indicators covering the United States and other advanced industrial societies at the detailed industry level using the best available information from both domestic and international public and private data sources. A considerable number of performance indicators at the 2, 3 and 4 digit SIC and ISIC code industry level, including data on productivity, value added, exports, profits, share prices, sales and employment rates have already been identified and collected. Also included in the database are alternative measures of performance, such as wages health and safety figures, and unemployment rates, as well as data on possible determinants of performance, including capital investments and R&D expenditures.

Principal Investigator: Professor Richard Lester
Project Director: Dr. Christopher Heye (IPC Visiting Scientist)

EDUCATIONAL ACTIVITIES

A key objective of the Industrial Performance Center is to develop new educational resources that will give our students a deeper understanding of how problems of industrial performance appear from the perspective of real world experience as contrasted with textbook theories; how core theories of disciplines other than their own treat these problems; and how different firms, different industries and different societies organize in different ways to solve them.

The center continues to sponsor an interdisciplinary graduate seminar for doctoral students from around the Institute who are engaged in research on subjects related to industrial performance. The seminar is led by Professor Tom Kochan. A new graduate research seminar was initiated this year in collaboration with the Department of Urban Studies and Planning. The focus was on the health of New England's manufacturing base and the changing mix of occupations and skill requirements in
the region's manufacturing industries. Three other new graduate courses growing out of the IPC's research are now being offered: *Technology, Productivity, and Industrial Competition*, *Information Technology as an Integrating Force in Manufacturing*, and *Domestic Impacts of Trade and Integration*.

**OTHER ACTIVITIES**

During the academic year, the center continued to sponsor the IPC faculty seminar. The seminar provides an interdisciplinary forum for faculty from across the Institute with a professional interest in questions of industrial productivity and performance to meet and discuss issues of common interest. Nearly 30 faculty from all five of the Institute's Schools are active participants in this series.

The center continues to play an important role in helping to develop intellectual connections and research collaborations among the Sloan Industry Studies.

In September 1993, the center hosted its first major international conference on "The Future of Industry in Advanced Societies." The conference was an outgrowth of the work of the MIT Commission on Industrial Productivity, whose report, *Made in America*, was published in 1989. Similar commissions were subsequently launched in France, Sweden and Japan, and delegations from each of these countries were invited to the conference to report on their findings. The conference was highly successful, attracting 150 leading practitioners and researchers in the field of industrial performance, and creating a foundation for a continuing set of interactions on this topic between research communities in several different countries. IPC faculty members were also active participants in the MIT-World Economic Forum Industry Summit, also held at MIT last fall.

**ORGANIZATION**

In January of this year, the administrative home of the Industrial Performance Center was shifted to the School of Engineering from the Office of the Provost, where it had resided for the first three years of its existence. The center will continue as an MIT-wide unit. Its Advisory Council is chaired in annual rotation by the Deans of the Schools of Management, Engineering, and Humanities and Social Sciences. Its staff consists of the director, Professor Richard K. Lester, the assistant to the director, Ms. Betty Bolivar, and the administrative assistant, Ms. Anne Flaherty.

RICHARD K. LESTER
The major innovation this past year was the formal launching of the multidisciplinary doctoral program in Technology, Management and Policy. This activity is sponsored by a core group of senior faculty in the Schools of Engineering, Management and Humanities. It represents a major effort to achieve and sustain long-term advanced interdisciplinary research and teaching between the technological departments and the applied social sciences at MIT.

The specific object of this doctoral program is to provide focus and coherence to the research efforts that seek to develop methods to improve the development and implementation of policies for the intelligent, wiser use of technology. This work is most important for society, since the existing methods of policy formation for technology are notoriously haphazard and ad hoc. The work thus seeks to fill a great intellectual and professional void.

Carrying out this agenda requires dual competence, at an advanced level, in specific fields of both technology and applied social sciences. Students are thus only admitted to this doctoral program once they have demonstrated these advanced professional capabilities through Master's degrees. Despite these stringent criteria, the demand for this program is high at MIT and nationally. The Technology, Management and Policy doctoral program thus already has over a dozen dissertation students.

Strong interest and growth in this multidisciplinary field is also apparent in the Master's Program in Technology and Policy. This program now recruits over 50 new students each year, from all the fields of Engineering at MIT, and has about 130 students on campus at any time. This program is oriented to professional practice, equally in government and in industry.

The students in both the Master's and the Doctoral Programs are highly competitive, since they must excel in two quite different fields and a most advanced level. They thus regularly receive MIT, national and international awards. One of the doctoral students, Judith Cardell, was honored at the MIT Awards Ceremony May for her outstanding excellence as a teaching assistant.

Richard deNeufville
This year the School of Humanities and Social Science (SHSS) continued to focus its efforts on curriculum reform, affirmative action, fund-raising, and faculty recruitment in departments and sections which are experiencing retirements and resignations, in particular Political Science, Economics, and Linguistics and Philosophy. The faculty within the School received a number of honors and awards, and some important administrative changes within the School have occurred.

**Undergraduate Education**

"Undergraduate Education in the Humanities, Arts and Social Sciences," a report based on a survey of the class of 1992, was disseminated in two parts; a statistical sketch based on an analysis of the academic records of 300 students, randomly and anonymously selected, and a summary of interviews conducted with 40 students (those who responded to randomly tendered invitations). Because of the richness of the HASS curriculum at MIT, and the diversity of choices made by individual students, the report offered few broad generalizations. It did note that student satisfaction with HASS offerings seemed high, measured both by their comments and by the fact that approximately 2/3 of the class of 1992 took more than the eight required HASS subjects; indeed more than a quarter took eleven.

A more focused report was produced by the committee appointed jointly by the Dean of the School of Humanities and Social Science and the Chair of the Committee on the Undergraduate Program (CUP) to conduct a six-year review of the HASS-D (Distribution) curriculum. Such a review was mandated by the faculty when it instituted the current distribution system. In general, the committee found that the HASS-D system was functioning well. One of the persistent sources of student and faculty discontent -- the need to devote much of the first week in oversubscribed classes to lotting out extra students -- was addressed this year by the introduction of a computerized lottery system, which assigns students to classes before the first meeting. The committee recommended loosening the requirement that all HASS-D subjects conclude with a final exam. This seemed especially appropriate since the CUP voted this year to terminate the experiment that exempted HASS-D subjects from the general prohibition of take-home final exams. The major problem that the review committee addressed was the role of category 3, Visual and Performing Arts, within the HASS-D requirement. At present, students must choose one subject from category 1 (Literary and Textual Studies) or category 2 (Language, Thought, and Value), one from category 4 (Social and Cultural Studies) or category 5 (Historical Studies), and one from a category not previously chosen. In order to erase the small distinction thus made between category 3 and the other categories, the review committee suggested that the requirement be slightly altered, so that students would choose one HASS-D subject from categories 1, 2, or 3; one from categories 4 or 5; and one from a category not previously chosen. This suggestion was accepted by the Council of the School of Humanities and Social Science but rejected by the CUP; the requirement therefore remains unchanged in this respect. The total number of HASS-D subjects to be offered in 1994-95 remains close to the target number of 75.

The number of students applying for a HASS Minor Program, an intermediate option between the HASS concentration of three of four subjects in a given field and the HASS major, remained approximately constant this year; at the end of 1994, 446 students were registered as candidates for a Minor, compared with 451 a year ago.

As a result of an MIT faculty vote in spring 1989, June 1994 Course XXI majors were the fifth class to graduate with degrees that designate their specific fields. Twenty-eight students received Course XXI degrees in February and June, including 10 who completed joint degrees with science or engineering.

**New Initiatives**

The School of Humanities and Social Science collaborated with the School of Engineering in offering a new Writing Initiative during AY 1993-94. The Initiative is designed so that writing subjects, called practica, each offering six units of HASS credit, are attached to existing engineering subjects. Each practicum is limited to 15 students, and
gives those students an opportunity to work intensively on writing assignments for the engineering subject; to prepare additional assignments (often dealing with managerial or organizational issues); to edit each other’s work; to develop leadership and discussion skills in a small group setting; and to give formal and informal oral presentations. Most of the practica are taught by graduate writing fellows who are selected, trained, and supervised by the three SHSS co-directors: Senior Lecturer Edward Barrett, Program in Writing and Humanistic Studies, Dean Leslie Perelman, Coordinator of the Writing Requirement, and Robert M. Metcalfe Associate Professor of Writing Rosalind Williams, faculty director.

The first year of the Writing Initiative was a resounding success. All of the parties involved agree that its basic structure is both robust and flexible, and that it fills an extremely important need in the non-technical education of MIT undergraduate engineering majors. The Initiative will offer sixteen practica in AY 94-95, and will continue with modest expansion for the following academic year with funding from the J. M. R. Barker Foundation and from the Metcalfe Chair. Further funds are being sought in order to maintain the Initiative beyond the first three-year pilot period and to expand it so that all undergraduates who wish to enroll in a practicum may do so.

Cultural Studies Project

The Cultural Studies Project sponsored a conference on Jane Austen in cultural context, as well as lectures on a variety of topics. Visiting scholars, who came for three days of intensive interaction with faculty and students, included Natalie Zemon Davis, Professor of History at Princeton University; David Bordwell, Professor of Film Studies at the University of Wisconsin; and Gillian Beer, Professor of English at the University of Cambridge. Effective July 1, Cultural Studies activities will be administered in the Dean’s office.

DIBNER INSTITUTE and BURNDY LIBRARY

The Dibner Institute for the History of Science and Technology had a successful year of operations; it had its first full complement of fellows in residence and it held several important conferences and workshops on such topics as *European Backgrounds to the American System of Manufacturing*, organized by Professor Merritt Roe Smith. In 1994-95, nineteen new fellows will be housed in the Dibner Building at 38 Memorial Drive.

An independent research consortium involving Harvard, Boston University, and Brandeis, but with its strongest ties to MIT and its Program in Science, Technology and Society, the Dibner Institute and Burndy Library have already made a sustained contribution to MIT’s international leadership in the study of the history of science and technology. Dibner Institute director, Professor Jed Buchwald, and executive director, Dr. Evelyn Simha deserve much credit for getting the Dibner Institute into full gear within two years.

Affirmative Action

The affirmative action record of SHSS appears to be strong relative to the rest of the Institute mainly because the representation of women within the fields of humanities and social science is relatively large. The School's record relative to the pool, however, is about average. Within the School for 1993-94 there were 34 women faculty, which represents 23 percent of the total. Of these 22 are tenured (20 percent of the tenured faculty). Over the past five years, the total number of women faculty has slightly increased (from 31 in 1988-89 to 34 in 1993-94). While we were successful in recruiting three women to the faculty for next year (one in Political Science, one in History, and one - a joint appointment with Sloan - in Economics), we lost two women owing to retirement and resignation. Therefore, the number of women faculty members will increase by one (to 35) next year.

The School’s record with respect to underrepresented minority faculty is much less satisfactory than it is with respect to women. There are currently three tenured (underrepresented) minority faculty members and three untenured (underrepresented) minority faculty members within the School. SHSS continues its commitment to increasing the number of underrepresented minority faculty, and to this end, the departments and sections within the School may not go forward with search plans without the determination of the relevant pool of minority appointments.
Moreover, the Dean has convened a school-wide affirmative action committee to investigate possible minority “target-of-opportunity” appointments. These efforts led to the successful recruitment of an African-American woman as assistant professor in Political Science, beginning next year. This appointment will increase the representation of untenured, underrepresented minorities next year by one (to four). The Department of Economics also made an offer of an assistant professor appointment to an African-American woman, but she elected to remain at Stanford University. The Program in Writing and Humanistic Studies vigorously pursued the senior appointment of an African-American essayist from Washington University, who ultimately decided not to leave the Afro-American studies program he had started, and an African-American woman from Princeton University, who declined in favor of a chaired position at Wesleyan University.

The School’s record with respect to underrepresented minority administrative staff members is slightly better, with two underrepresented minorities of a total of 21 (10%). SHSS reduced the number of administrative staff positions for next year by one (from 22 to 21), by unifying the administrative functions of the Programs in Anthropology/Archaeology and Science, Technology and Society (STS). The School remains committed to increasing the number of minority faculty and administrative staff members.

Honors and Awards

The faculty within the School of Humanities and Social Science garnered an impressive array of honors and awards this year. The most notable among them were the following: Professor John Harbison of the Music and Theater Arts Section became the first member of the Humanities to be awarded the prestigious Killian Faculty Achievement Award. Professor Isabelle de Courtivron, of the Foreign Languages and Literatures Section, was named Class of ’60 Fellow, a scholarly award for “distinguished leadership in teaching, commitment to educational innovation, and service to the education community.” Professor Merritt Roe Smith was selected as the first holder of the Leverett Howell Cutten ‘07 and William King Cutten ’39 Professorship. The Department of Economics’ Professor Peter Diamond is the first winner of the $100,000 Nemmers Prize awarded by Northwestern University; Institute Professor Robert Solow received an Honorary Doctor of Science from Rutgers University; and Assistant Professor Jonathan Gruber has been selected as the next holder of the Castle Krob Career Development Chair. Associate Professor Henry Jenkins III of the Literature Section was selected as the Class of ’42 Career Development Professor, and Assistant Professor Michael Kremer of the Department of Economics was awarded the Pentti J. K. Kouri Career Development Chair. Assistant Professor Hugh Gusterson, who holds a joint appointment with the Programs in Anthropology/Archaeology and Science, Technology and Society (STS), received the Levitan Prize in the Humanities. The Literature Section’s Professor John Hildebidle was awarded a Fulbright Fellowship for study in Ireland, and Professor David Halperin was in residence at Cornell University as a Fellow of the Society for the Humanities. He also received the Michael Lynch Service Award from the Gay and Lesbian Caucus of the Modern Language Association. Associate Professor Jonathan Fox of the Department of Political Science was awarded an international affairs fellowship by the Council on Foreign Relations. The Department of Political Science’s Professor Suzanne Berger received the “Mentor of Distinction” Award from the American Political Science Association, and Professor Charles Sabel received the Graduate Student Council Award for outstanding teacher. Assistant Professor Evelyn Hammonds of the Program in Science, Technology and Society was awarded a fellowship at the Institute for Advanced Study at Princeton University; the Program’s Professor Emeritus and Senior Lecturer Leo Marx was awarded the Hubbell Medal by the Modern Language Association for lifetime contribution to the study of American Literature. Associate Professor Abhijit Banerjee of the Department of Economics received a Sloan Research Fellowship. The Program in STS’ Professor Loren Graham was elected Foreign Member of the Academy of Natural Sciences, Moscow, Russia, and Associate Professor Deborah Fitzgerald was elected to the Executive Council of the Society for the History of Technology. Professor Paul Joskow of the Department of Economics won the Best Paper Award from the International Association for Energy Economics.

Fundraising

The School continued its efforts to raise funds from foundations, corporations and individual donors, as well as from federal sponsors, to support various educational and research programs.
The World Economy Laboratory received two major grants: a $1.2 million grant over four years from the Federal Republic of Germany to study the economic consequences of German reunification; a $400,000 grant from the Ford Foundation to organize a two-year series of conferences on economic transition in Russia.

The MIT-Japan Program, part of the Center for International Studies, received a continuation grant of $1.85 million over two years from the Air Force Office of Scientific Research to support its program of preparing MIT students for internships in Japanese industry and offering training in Japanese studies to managers in U.S. industry and government.

The Foreign Languages and Literatures Section received two grants to support the development of interactive computer programs for Japanese instruction, $180,000 from the Department of Education and $100,000 from the National Endowment for the Humanities.

Efforts to raise funds from individuals met with moderate success during FY94. Pledges and gifts in the $25K and $50K range continued to be received from the School’s relatively small pool of alumni. Thanks to the efforts of the Chinese Alumni of MIT Association (CAMIT) the Chinese Language Program continued to receive widespread, if modest, support from their members. The first $250,000 of a $500,000 pledge was received from Mr. and Mrs. Usman Admadjaja of Indonesia for the support of Chinese language and cultural studies.

Administrative Changes, Retirements

This academic year has seen three retirements, four faculty terminations, and eleven new faculty appointments within the School. As of June 30, 1994, Professor Jerome Rothenberg of the Department of Economics, Professor Donald Blackmer of the Department of Political Science, and Professor Richard Cartwright of the Department of Linguistics and Philosophy retired from the faculty. We wish them great success in all their future endeavors as emeriti professors of MIT. The four faculty terminations included one due to the denial of tenure in the Literature Section, one in the History Section, one in the Department of Political Science, and one in the Department of Economics.

The School was successful in recruiting nine new members to the faculty for 1994-95. They include three in the Department of Economics, two in the Department of Political Science, two in the Department of Linguistics and Philosophy, one in the History Section, and one in the Literature Section.

In academic year 1994-95 the Anthropology/Archaeology Program will have Professor Jean Jackson as Acting Head for the year, while the current Head (Professor James Howe) is on leave. Professor Stanley Fischer of the Department of Economics will take a leave of absence to assume the post of First Deputy Managing Director of the International Monetary Fund in Washington, D.C. and will step down as Head of the Department on August 31, 1994. Professor Paul Joskow will replace Professor Fischer as Head. Dr. David Lundberg, who has served the School of Humanities and Social Science as its development officer since 1988, will leave MIT, effective August 1, 1994. He will assume a development position at the University of California at Los Angeles.

PHILIP S. KHOURY
TABLE I
ENROLLMENT IN HUMANITIES, ARTS, AND SOCIAL SCIENCE SUBJECTS:
1993-94

<table>
<thead>
<tr>
<th>Field</th>
<th>Elective Subjects</th>
<th>HASS-Distribution</th>
<th>Total Enrollments</th>
</tr>
</thead>
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<td></td>
<td>#Subjects (#Sections)</td>
<td>#Students</td>
<td>#Subjects (#Sections)</td>
</tr>
<tr>
<td>Anthropology/Archeology</td>
<td>13 (13)</td>
<td>184</td>
<td>6 (6)</td>
</tr>
<tr>
<td>Economics</td>
<td>23 (48)</td>
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</tr>
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<td>3 (4)</td>
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<tr>
<td>Writing</td>
<td>32 (49)</td>
<td>730</td>
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</tr>
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<td><strong>TOTALS</strong></td>
<td>340 (421)</td>
<td>6461</td>
<td>105 (134)</td>
</tr>
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</table>

Notes:
1.- Figures were obtained from the grade/subject distribution report which shows the final tally for each class.
2.- The numbers shown are for undergraduate subjects which normally satisfy the HASS Requirement; they do not include subjects allowed by petition.
3.- (#Sections) refers to the number of autonomous class sections; it does not apply to subjects which meet in a single lecture and divide into discussion sections.
4.- For Joint Subjects, figures are given for the subject number under which students enrolled.

*Music and Theater Arts 6-unit performance subjects are not included in these statistics.
### Fields of Concentration

<table>
<thead>
<tr>
<th>Fields of Concentration</th>
<th>Class of 1997</th>
<th>Class of 1996</th>
<th>Class of 1995</th>
<th>Class of 1994</th>
<th>Totals in Fields</th>
</tr>
</thead>
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</tr>
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<td>0</td>
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<td>Film &amp; Media Studies</td>
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<td>(9) 2</td>
<td>(7) 7</td>
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<td>254</td>
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<td>73</td>
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<td>(10) 5</td>
<td>5</td>
</tr>
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<td>(0) 0</td>
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<td>0</td>
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<td>(48) 13</td>
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<td>81</td>
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<td>(26) 22</td>
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<td>(15) 0</td>
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** The parenthetical figure is the number of proposed concentrations in the given class and field; the figure to its right is the number of these concentrations that have been completed.

** Figures for subfields of Foreign Languages and Literatures:

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<tr>
<th>Subfields</th>
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<th>Class of 1995</th>
<th>Class of 1994</th>
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<td>(23) 13</td>
<td>(60) 54</td>
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<td>(29) 3</td>
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<td>(35) 3</td>
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TABLE III

Undergraduate Majors in the School of Humanities and Social Science

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<th>Year</th>
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<th>Philosophy</th>
<th>Political Science</th>
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<td>26</td>
<td>134</td>
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<td>57</td>
<td>7</td>
<td>21</td>
<td>134</td>
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<td>76</td>
<td>77</td>
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<td>40</td>
<td>202</td>
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<td>11</td>
<td>43</td>
<td>209</td>
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<td>54</td>
<td>229</td>
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<td>13</td>
<td>44</td>
<td>236</td>
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*These figures do not include double majors who registered first in a course other than Humanities. (If you include double majors, the figure is 83.)

TABLE IV

Graduate Students in the School of Humanities and Social Science

<table>
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<tr>
<th>Year</th>
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<th>Linguistics &amp; Philosophy</th>
<th>Poli Sci</th>
<th>Total</th>
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<td>—</td>
<td>53</td>
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<tr>
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<td>—</td>
<td>59</td>
<td>171</td>
<td>360</td>
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<td>1986-87</td>
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<td>—</td>
<td>55</td>
<td>115</td>
<td>275</td>
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<td>—</td>
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<td>157</td>
<td>349</td>
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<td>67</td>
<td>118</td>
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<td>154</td>
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<td>362</td>
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<td>1991-92</td>
<td>139</td>
<td>17</td>
<td>53</td>
<td>160</td>
<td>369</td>
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<tr>
<td>1992-93</td>
<td>149</td>
<td>21</td>
<td>57</td>
<td>154</td>
<td>381</td>
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<td>24</td>
<td>50</td>
<td>138</td>
<td>355</td>
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### TABLE V

**HASS MINOR APPLICATIONS**


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<td>Film and Media</td>
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<td>French</td>
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<td>German</td>
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<td>History</td>
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<td>History of Art and Architecture</td>
<td>4</td>
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<td>Linguistics*</td>
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<tr>
<td>Writing</td>
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</table>

**Total Minor Applications** 446

Staff in the HASS Office worked with Information Systems and others to implement in Spring Semester 1994 the "HASS-D Selection System," a computerized lottery for HASS-Distribution subjects which students access through Athena. This new system enabled 93% of students to enroll in their first-choice HASS-D subject, and led to a higher level of satisfaction for both students and faculty. The Coordinator of the office, Dr. Bette Davis, also served as staff to the HASS-D Review Committee. The Committee conducted a six-year review of the HASS-D system, as mandated by the MIT Faculty, and reported to the CUP in the spring.

In addition, the HASS Office continued to serve multiple functions, including the administration of the eight-subject HASS requirement, the HASS Minor, the Harvard Cross-Registration Program, provision of statistics for the School of Humanities and Social Science, and the publication of the HASS Guide each term. This office has the responsibility, on behalf of the Registrar's Office, of recording proposal and completion forms for both concentrations and minors on each student's record. Petitions for HASS credit for subjects which are not so coded, such as Harvard and Wellesley subjects, graduate subjects, etc., are submitted here for approval. Information concerning any of the above, as well as HASS transfer credit and general Institute information, was provided to the MIT community and in response to inquiries from outside the Institute. The Coordinator, Dr. Bette Davis, again served as staff to the HASS-D Overview Committee and the HASS Minor Committee.

HASS ENROLLMENT STATISTICS BY FIELD AND SUBJECT - - RECENT TRENDS
The number of HASS subjects offered in 1993-94 increased from 415 to 445, with the number of autonomous sections also increasing from 533 to 555. There was a slight decrease in the number of HASS-D subjects offered, from 113 to 105, with approximately 100 fewer students enrolled. The largest overall enrollments were in the same fields as last year, in the same order: 1649 in Foreign Languages and Literatures, 1585 in Economics, and 887 in Literature. Literature was closely followed by Music (865) and Writing (858). The following fields showed the greatest increases in enrollments over last year, in terms of percentage: STS (from 189 to 280), Political Science (from 404 to 512), History of Art and Architecture (from 99 to 126), and Anthropology/Archaeology (from 359 to 454).

HASS CONCENTRATIONS: PATTERNS OF POPULARITY
Economics and Foreign Languages again topped the list of completed HASS Concentrations: in 1993-94, 269 students completed concentrations in Economics, and 254 students completed concentrations in Foreign Languages. (For a breakdown by language, please see Table II.) Following Economics and Foreign Languages in the number of completed concentrations are Music (107), Psychology (81), and History (73).

HASS MINOR PROGRAMS
After dropping off slightly last year, the number of HASS minors remained approximately constant this year. In 1993-94, 446 minor applications were filed, compared to 451 last year. The three most popular fields in terms of applications filed are the same as last year: Economics (130), Music (65), and Literature (39). These were followed by Writing (30), Political Science
and Psychology and German, with 21 each. HASS Minors were received by 171 members of the Class of 1994; the order of the four most popular fields is the same as for the total number of applications filed: Economics (50), Music (29), Literature (18), and Writing (16). One new HASS Minor Program was approved during 1993-94, in Linguistics.

HARVARD CROSS-REGISTRATION
It is difficult to analyze the fluctuations in numbers of MIT undergraduates cross-registering for courses at Harvard. Numbers were high in 1990-91, low in 1991-92, higher again in 1992-93, and down again this year, 1993-94. In 1993-94, 157 MIT undergraduates took 176 subjects at Harvard, compared to 191 students enrolled in 209 subjects in 1992-93. Foreign languages continue to be the most popular field. Enrollments in this area were quite widely dispersed among 16 different languages, but the largest numbers were in Chinese (16), Korean (9), and Italian (8). The most popular fields outside foreign languages and literatures were Biology and Biological Sciences (18) and Economics (10).

S.B. DEGREES GRANTED IN THE SCHOOL OF HUMANITIES AND SOCIAL SCIENCE (SHSS)
In Course 14, Economics, 36 students received the S.B. degree, while 10 students received degrees in Political Science, Course 17. During the same time period, September 1993 through June 1994, a total of 28 students completed their S.B. in Humanities, Course 21. Of these, 10 received joint degrees, one in 21-E, and nine in 21-S. Another 18 received degrees in a specific field within Course 21. Four undesignated Humanities degrees were granted in June 1994. One student received an S.B. in Philosophy, Course 24.

UNDERGRADUATE MAJORS IN SHSS
The Economics Department has 79 undergraduate majors, whereas 25 undergraduate students are majoring in Political Science. (These are first degrees.) As of May 1993, 83 students had declared a major in Humanities. Of these, 25 were joint majors (10 in XXI-E and 15 in XXI-S). Writing had the most majors (20), followed by Music (19) and History (11). Five undergraduates have officially declared majors in Philosophy.

HONORS AND AWARDS GRANTED TO UNDERGRADUATE MAJORS IN SHSS
Among the more notable honors achieved by SHSS majors this year were:
Rhodes Scholar: Eileen Brooks '94
Burchard Scholars: Oded Asherie '96, Ximena Leroux '96, Carrie Muh '96, Catherine Mangion '95, Edward Miguel '96
I. Austin Kelly III Prize: Pelarin Bacos III '94, Adrian Childs '94
Robert A. Boit Writing Prize: Hilary Bromberg '94, Shane Crotty '96; Honorable Mention: Todd Boutin '96
Boit Manuscript Prize: Cecilia Oh '94
Jeffrey L. Pressman Award: Robert Fowler '96
Louis Sudler Prize: Christopher Adler '94
Tau Beta Pi: Namuk Cho '94, Tolga Uzuner '94
Gregory Tucker Memorial Prize: Adam Lindsay '94
Philip Loew Memorial Award: Pelarin Bacos III '94
Peter J. Eloranta Award: Hilary Bromberg '94, Oded Asherie '96
INTRODUCTION

The scientific and academic activities of the Economics Department continued at a strong pace during the year. As in previous years, members of the faculty participated actively in both national and international policy issues. Two new senior appointments were made in the areas of applied theory and industrial organization. Two junior faculty appointments were made in the areas of theory and industrial organization. The Department also was successful in recruiting new graduate students for the fall term in 1994.

FACULTY PERSONNEL

The Department is delighted that Professor Bengt Holmstrom will be joining the faculty July 1, 1994. Professor Holmstrom, from the Yale School of Organization and Management, is considered one of the world's preeminent organizational theorists. Professor Holmstrom will be an invaluable asset to the Department as it rebuilds its theory group. Associate Professor Nancy Rose of the Sloan School, whose areas of research and teaching are the economics of regulation, industrial organization, and applied economics, accepted our offer and will join the Department July 1, 1994. She will hold a joint appointment with the Economics Department and the Sloan School. Associate Professor Glenn Ellison, a very promising game theorist with industrial organization interests, will join the faculty on July 1, 1994. He has been appointed the Ford Career Development Associate Professor. Professor Ellison comes to us from Harvard University.

The Department also has hired Alberto Bisin as an assistant professor. Professor Bisin, who specializes in the areas of general equilibrium theory and the theory of growth, received his Ph.D. from the University of Chicago and last year took a one-year European post-doctoral fellowship at DELTA in Paris.

Professor Abhijit Banerjee, a theorist with interests in the area of international development, and Professor Ricardo Caballero, a macroeconomist, have been approved for promotion to associate professor with tenure effective July 1, 1994.

Professor Paul Krugman has resigned from the Department to accept an offer from the department of economics at Stanford University.

Professor Jerome Rothenberg has formally retired effective June 30, 1994. He will continue to be active in the Department as a senior lecturer.

Senior faculty members on leave for all or part of this year were Professors Richard Eckaus, James Poterba, and Paul Krugman. Professor Eckaus continued his research in international development and Professor Poterba spent a year at the Center for Advanced Study in the Behavioral Sciences at Stanford University. Professor Krugman was on leave at Stanford University for the spring semester.

There were four visiting faculty and one visiting lecturer this year. Professor Jean Tirole, of the University of Toulouse, taught a topics course in industrial organization. Associate Professor Steven Davis, of the University of Chicago, taught Special Topics in Economics and Labor Economics I and II. Assistant Professor Matthew Rabin, of the University of California at Berkeley, taught Economic Applications of Game Theory, Micro Theory, and Game Theory. Assistant Professor Lars Stole, of the University of Chicago, taught Contract Theory and Industrial Organization. Visiting Lecturer Eytan Sheshinski, of the Eliezer Kaplan School of Economics and Social Science at The Hebrew University, taught Public Finance with Assistant Professor Jonathan Gruber.

The Department maintains its concern with increasing the representation of women and minorities in the economics profession. The Department has contacted the top 50 economics departments in the US to identify women and minority candidates. This information will be reviewed carefully over the next year to identify any outstanding candidates for our Department. We made two offers to women this year. Associate Professor Nancy Rose accepted our offer. Unfortunately, Robin Wells, a minority candidate from the Stanford Business School, declined our assistant professor offer.
STUDENT RECRUITMENT AND ENROLLMENT

The recruitment of graduate students continued to be highly competitive with other major graduate programs. The leading applicants for admission were again invited to visit the Department, as is now done by all of the top graduate economics departments. This year's class of 28 will include 16 international students and 10 women (36 percent). The number of women students enrolled is up 20 percent over last year. Twenty-five percent of our entering class have National Science Foundation Fellowships or Jacob Javits Fellowships to begin their graduate studies in economics. This figure is down slightly (6 percent) over last year.

Undergraduate enrollment increased slightly this past year. There were 79 undergraduate majors in economics (excluding double majors) and 120 undergraduate minors last year. The total enrollment in all undergraduate subjects in economics this year was five percent greater than last year.

FACULTY RESEARCH

Faculty research continues to be intense and highly productive. Following are examples: "Learning About Others' Actions and the Investment Accelerator" (Assistant Professor Daron Acemoglu); "Least Squares Estimation of a Shift in Linear Processes" (Assistant Professor Jushan Bai); "The Role of Poverty in Development Theory" (Associate Professor Banerjee with A. Newman); "Human Capital, Inequality and Growth: A Local Perspective" (Associate Professor Roland Benabou); Post Communist Reform (Professor Olivier Blanchard); "Pension Reform in a Transition Economy: Notes on Poland and Chile" (Professor Peter Diamond); "Health and Labor Force Participation, 1900-1991" (Assistant Professor Dora Costa); "The Cleansing Effect of Recessions" (Associate Professor Caballero with M. Hammour); Stabilization, Debt and Reform (Professor Rudiger Dornbusch); "A General Equilibrium Analysis of the Effects of Carbon Emissions Restrictions in a Developing Country" (Professor Eckaus); Securing Peace in the Middle East (Professor Stanley Fischer with L. Hausman, A. Karasik, and T. Schelling, eds.); "The Production-Theoretic Measurement of Input Price and Quantity Indices" (Professor Franklin Fisher); "Adverse Selection in the Wholesale Used Car Market" (Assistant Professor David Genesove); "The Incidence of Mandated Maternity Benefits" (Professor Gruber); "Cigarettes Can Take a Substantial Tax" (Associate Professor Jeffrey Harris); "Valuation of New Goods Under Perfect and Imperfect Competition" (Professor Jerry Hausman); "More From the Guru of Energy Efficiency" (Professor Paul Joskow); "Can Having Fewer Partners Increase the Prevalence of AIDS?" (Assistant Professor Michael Kremer); "The Asymptotic Variance of Semiparametric Estimators" (Professor Whitney Newey); "Existence of Fair Allocations in Economics with Production" (Assistant Professor Thomas Piketty); "Corporate Reform in American Manufacturing and the Challenge to Economic Theory" (Professor Michael Piore); "Racial Violence in Germany" (Assistant Professor Jorn-Steffen Pischke with A. Krueger); "Targetted Retirement Saving and the Net Worth of Elderly Americans" (Professor Poterba); "Neighborhood Externalities and Housing Homogeneity" (Professor Jerome Rothenberg); "Optimal Search in a Changing World" (Assistant Professor Lones Smith); "Two (or Three) Ways of Thinking about Unemployment" (Professor Robert Solow); "Three Shocks, Two Recoveries? Historical Parallels Between the End of the Cold War and the End of the World Wars" (Professor Peter Temin with C. Feinstein and G. Toniolo); "Office Rent Indices and their Behavior over Time" (Professor William Wheaton).

FACULTY HONORS

Institute Professor Solow received an Honorary D.Sc. from Rutgers University in May and Professor Diamond is the first winner of the $100,000 Nemmers Prize awarded by Northwestern University to the person who has produced an especially significant body of work. Professor Blanchard was awarded the Silver Medal for his paper submitted to the international American Express Competition. Professor Gruber has been selected as the next holder of the Castle Krob Career Development Chair effective July 1, 1994. He has received grants from the National Institute of Aging and the Advisory Council on Unemployment Compensation. In addition, this year Professor Gruber was the recipient of the Department's Undergraduate Teaching Award. Professor Kremer has been named to the Pentti J. K. Kouri Career Development Chair effective July 1, 1994. Professor Banerjee has received a Sloan Research Fellowship. Professor Joskow won the Best Paper Award from the International Association for Energy Economics.

FACULTY PROFESSIONAL AND PUBLIC ACTIVITIES

The Department's faculty continue to give many invited lectures, appear at conferences and perform many functions in professional groups and other public services. Professor Diamond chaired the MIT ad hoc committee on the closing of
CMRAE. Professor Caballero was selected as a National Bureau Research Associate. Professor Eckaus gave the Thirteenth Alex Eckstein Lecture at the Center for Chinese Studies at the University of Michigan in March. In June, Professor Fischer gave the keynote address at the 300th Anniversary Celebration of the Bank of England. In November, Professor Harris presented his paper, "The Health-Care Costs of Cigarette Smoking" before the Committee on Ways and Means, U.S. House of Representatives in Washington, DC. Professor Piore is an elected member of the Executive Board, American Economic Association. Professor Pischke was a member of the Program Committee of the 1994 European Economic Association Meeting. Professor Poterba is a member of the Nominating Committee and the Program Committee of the American Economic Association. Professor Poterba also is the Director of the American Finance Association, 1993-1996. Institute Professor Solow gave the Lionel Robbins Lecture in Claremont, California and the Cyprus Economics Society Lecture in Nicosia, Cyprus.

DEPARTMENTAL GIFTS AND RESEARCH GRANTS

The Department continues to receive financial support from its alumni and friends. We have established the George and O'Bie Shultz Fund to provide research assistance to graduate students working on their theses who are going outside of MIT to gather data and to understand the markets they are analyzing. This fund was established by a generous initial grant and followed by a substantial installment this year. Since the funds have been placed in an endowment fund, however, the income available for research support is still quite limited.

The World Economy Laboratory (WEL) continues to raise funds for the Department. On the inside, WEL makes resources available to support policy research, especially for young faculty, students, and special visitors. On the outside, WEL continues to communicate its research findings to a broad audience. During fiscal year 1994, WEL sponsored four conferences: two in Washington, DC and one each in Peru and Italy. Funding has been received this year from the Ford Foundation (Russian economy) and the German government (German economy). In addition, WEL continues to receive support from its many corporate sponsors and members. WEL is now providing initial funding for new and ongoing research being done in the Department and plans to expand that support in the future.

The Department continues to upgrade its investment in the Computer Cluster which enables empirical research to be done at the most advanced professional level as well as interface with Athena for teaching and student use. While resources for this initiative are slim, the Department has no choice but to maintain a first-class computing facility.

The National Science Foundation continues to award grants to the Department's faculty. Professor Diamond received a grant for his project entitled, "Uncertainty, Social Insurance, and the Micro Foundations of Macroeconomics" and Professor Blanchard received a grant for his project entitled, "Transition in Eastern Europe." Professor Kremer received a grant for his project entitled, "Labor Markets and Epidemics."

Stanley Fischer
RESEARCH AND PUBLICATION
Books by two faculty members will appear during the coming academic year. During the fall term MIT Press will publish Associate Professor Dorothy Hosler's Sounds and Colors of Power: Sacred Metallurgy of Ancient West Mexico. Assistant Professor Hugh Gusterson's Testing Times: A Nuclear Weapons Laboratory at the End of the Cold War, accepted by University of California Press, has been revised for publication. Professors Martin Diskin, James Howe, and Jean Jackson have book manuscripts nearly completed.

Articles and book chapters published or in press indicate the scope of research by Program members. They include Professor Jackson's "The Rashomon Approach to Dealing with Chronic Pain" (Social Science and Medicine); Professor Gusterson's "Realism and the International Order after the Cold War" (Social Research); a chapter by Professor Hosler entitled "The Metallurgies of the Americas" in The Oxford Encyclopedia of Archaeology; an article by Professor Arthur Steinberg, "Blurred Boundaries, Opulent Nature, and Sensuous Flesh: Changing Technological Styles in Venetian Painting, 1480-1520" (Studies in the History of Art); and "Sounds Heard in the Distance: Poetry and Metaphor in the Kuna Struggle for Autonomy" (Journal of Latin American Indian Literatures) by Professor Howe. Program members delivered papers at a variety of conferences and seminars, both in the United States and abroad.

AWARDS AND GRANTS
The Program's two junior faculty members both received honors during the current year. Professor Gusterson won the MIT Levitan Prize. Professor Hosler will spend May of 1995 as Invited Professor at L'Ecole des Hautes Etudes en Sciences Sociales in Paris. Professor Hosler has also been named to the governing board of the Presley Norton Foundation for Archaeological Research. Professor Howe has received a grant for field research in Panama from the Whiting Foundation, and Dr. Niels Braroe, a visiting scholar in the Program, has had a grant from NIH renewed for research on Indian-White Relations in Canada.

PROGRAM ACTIVITIES
The seminar series at the MIT Center for International Studies, "Peoples and States: Ethnic Identity and Conflict," completed its fifth year, with two of its speakers jointly sponsored with the Ford series. Cultural anthropologists in the Anthropology/Archaeology Program continued to play an active part in the doctoral program in the History and Social Studies of Science and Technology. Professor Steinberg's activities as head of the Integrated Studies Program are described in the section devoted to ISP.

PERSONNEL CHANGES
Several faculty members were away from the Program during 1993-94. Professor Diskin has been on long-term disability leave. Professor Hosler, in Ecuador during the fall term, contracted a serious illness there and had to spend the Spring term recovering. The Program is delighted that both will return to teaching in September.
1994. Professor Steinberg was on leave during the Spring term, Professor Jackson for the academic year. Professors Gusterson and Howe will both be on leave during 1994-95.

During Professor Howe's leave, Professor Jackson will fill the position of Program Head, which she held until this year. Professor Howe will resume the headship in July of 1995.

The position of Administrative Officer for the Program has been eliminated as of July 1, 1994. Program faculty deeply regret the departure of Ms. Priscilla Cobb, who has managed the Program with dedication, skill, and a great fund of humor and good cheer.

Opportunities for Affirmative Action initiatives were very limited this year, because the Program did not run any faculty searches and an administrative position was eliminated; the number of faculty members in residence was also very small. Program leaders are exploring the possibilities in the coming year of an appointment under the auspices of the Provost's initiative.

James Howe
During the academic year 1993-94, members of the faculty of Foreign Languages and Literatures (FL&L) continued to provide national and international leadership in the fields of foreign language pedagogy, technology in the humanities, and literary and cultural studies while demonstrating their commitment to excellence in education within the Institute. In May, Isabelle de Courtivron, Professor in French Studies and Section Head, was named as the Class of '60 Fellow, a scholarly award for "distinguished leadership in teaching, commitment to educational innovation and service to the education community." During the Spring semester, Shigeru Miyagawa, Professor of Linguistics and Japanese, was appointed Acting Head while Professor de Courtivron was on sabbatical in Paris, France.

The FL&L section along with the Laboratory for Advanced Technology in the Humanities (LATH) and the Language Learning and Resource Center (LLARC) has been on the cutting edge of research by continuing award-winning work on several interactive video projects. They include: *Tanabata: The Star Festival*, an interactive-video for Japanese language learning; *Dans le Quartier St. Gervais*, a French language learning interactive video, *No recuerdo*, an interactive narrative documentary for Spanish language; *The Fourth of July*, an interactive video for English as a Second Language; *Shakespeare Interactive Archive Project*, an electronic archive and classroom presentation system linking important performances of Shakespeare's plays, co-directed by Professor Peter Donaldson, Head of MIT's Literature Section; and *Berliner sehen*, an interactive documentary for German language learning. These projects have received several grants during the past year. The National Endowment for the Humanities has demonstrated its support of the interactive video projects with new grants for *Tanabata* and continued its support of *Shakespeare* and *No recuerdo*. *Tanabata* has received new support from the US Department of Education and the ASCII Corporation of Japan. The Consortium for Foreign Language Teaching and Learning remains a strong supporter of the efforts in FL&L projects on the Holocaust, English as a Second Language and networking Japanese by creating a local and global network for teaching and learning Japanese.

The FL&L faculty continue to advance their research in the areas of literary and cultural studies, linguistics and language pedagogy. Professor de Courtivron published "Mémoire et oubli: Women of the French Resistance" in *Contemporary French Civilization*. James Harris, Professor of Spanish and Linguistics published "Integrity of prosodic constituents" in *The View from Building 20*. Professor Miyagawa's article "Case checking" was published in *Case and Agreement*, Vol. 2. A chapter entitled, "Deriding the Voice of Jeanette MacDonald: Notes on Psychoanalysis and the American Film Musical" by Edward Baron Turk, Professor of French Studies and Film, appeared in *Embodyed Voices: Female Vocality in Western Cultures*. Professor Suzanne Flynn, Associate Professor of Linguistics and Second Language Acquisition, published "Why do Japanese speakers object to English objects" and "Explanation in Second Language Acquisition." Elizabeth Garrels, Associate Professor of Hispanic Studies, published "Sarmiento and the Woman Question: from 1839 to the *Facundo*" which appeared in *Sarmiento: Author of a Nation* (University of California Press). Margery Resnick, Associate Professor of Hispanic Studies, contributed to *Spanish Women Writers* with an article on "Carme Riera." Kurt Fendt, Research Associate and Lecturer in German, published "Hypertext und Medienintegration: Ansätze zum Gebrauch moderner Medien beim Lernen Fremder Sprachen" in *Studien zu Deutsch als Fremdsprache* (Zurich).

FL&L faculty continue to be involved internationally in the field of language pedagogy and have been invited to several conferences held around the world. Senior Research Scientist Janet Murray and Senior Lecturer Gilberte Furstenberg, Lecturer in French, were both guest lecturers at the University of Paris VII (Jussieu) in a program entitled *Exploitation didactique de l'image animée*. In addition, Senior Lecturer Furstenburg was a presenter at EXPOLANGUES, an international exposition of language learning technology held in Paris in February and attended the 11th International Conference on Technology and Education held in London in March. Associate Professor Flynn spoke at *Language and Education in a Changing World* at Trinity College in Dublin, Ireland. Professor Harris was an invited speaker at a conference entitled *1 Mes Redonda de Lingüística Española* at the Universidad Autónoma Metropolitana in Mexico City.

FL&L faculty members have planned and participated in several conferences both nationally and at MIT. In April, the first ever national conference on Japanese language teaching and learning was held at MIT assembling over 320 language teachers. This conference attracted Japanese teachers from around the United States and was highlighted by the introduction of the interactive video, *Tanabata*. In June, the LATH and LLARC co-hosted "Integrating Interactive Technologies into the Humanities Curriculum" which attracted teachers and researchers both from the US and abroad. Martin Roberts, Assistant Professor of French Studies participated in an MIT Communications Forum with "Democracy in Cyberspace: Society, Politics and the Virtual Republic." Professor Turk headed *Landmark Technicolor Musicals*, a special program at the Museum of Fine Arts, Boston, MA.

FL&L Faculty members continue to serve on a number of Institute-wide committees: President's Calendar Committee, The Equal Opportunity Committee, MIT Academic Computing, Regional Minors Committee; Committee on the Writing
Requirement Technology and Humanities Committee, Cultural Studies Steering Committee, Women’s Studies Steering Committee, Phi Beta Kappa Selection Committee, among others. In addition, Associate Professor Flynn has been named the chair of the Committee on Curricula.

FL&L has placed significant importance on making full-time appointments in order to decrease the number of part-time faculty. After conducting national searches for Lecturers in Japanese and English as a Second Language, several new lecturers were selected. In Japanese, Tomoko Graham, Masami Ikeda, and Yoshimi Nagaya were chosen. Along with these appointments in Japanese, two full-time lecturers were selected in English as a Second language, Mary Christie and Erika Mitchell. FL&L remains committed to the Institute’s policy of Affirmative Action; presently women constitute more than 75 percent of the Section’s faculty and staff. This year, vigorous efforts were made by each search committee to attract qualified candidates from minority groups by targeting historically black colleges and universities and advertising in several journals focusing on the minority community. In May 1994, Professor Flynn was promoted from Associate Professor to Full Professor effective July, 1994.

While the number of majors in FL&L remains low at four, the number of concentrators has increased markedly from 459 to 541, and the number of minors has remained steady at 56. Spanish continues to have the largest enrollments, 375; followed by Japanese 359; French, 267; German 190; English as a Second Language, 186; Chinese 145; and Russian, 76. In addition, enrollments in Studies in International Literatures and Cultures (cross-cultural language and culture subjects taught in English) remain high at 154. FL&L subjects make up an important component of the regional minors programs with 23 students enrolled. FL&L faculty and staff received some of the highest ratings in the Student Course Evaluation Guide.

In response to continued interest in East Asian languages and cultures, efforts to attract support from around the world have increased. In September and January, Professor Miyagawa and Dean Philip Khoury, Dean of the School of Humanities and Social Science traveled to Japan and met with officials from several Japanese governmental and private agencies to secure funding. MIT alumni have also lent a significant amount of support in the efforts to expand the East Asian language program.

Finally, renovations have been completed on four classrooms converting them for teaching with interactive video, film and recording equipment. These renovations were made possible through funds from the office of Dean of the School of Humanities and Social Science.

SHIGERU MIYAGAWA, ACTING HEAD
History Section

RESEARCH AND PUBLICATIONS
Three of the senior faculty in history produced major books this year. Henry R. Luce Professor John Dower published *Japan in War and Peace*, a collection of his essays; Professor Bruce Mazlish co-edited *Conceptualizing Global History*. Professor and Dean Philip Khoury co-edited two volumes: *The Modern Middle East: A Reader*, and *Recovering Beirut: Urban Design and Post-war Reconstruction*.

FACULTY APPOINTMENTS
In December of 1993, Professor Alexander Keyssar notified the department that he would not be returning to MIT. The department began a search for a new junior appointment in nineteenth-century American history. The search concluded with a successful offer to Heather Cox Richardson [Ph.D., Harvard], whose forthcoming manuscript discusses the evolution of the economic policy of the Republican party during the Civil War. Affirmative action considerations worked effectively during this search, bringing many women candidates to our attention. The full-time faculty of 15 now includes five women, of whom one is African American. The department continues to look for target of opportunity appointments for minorities and women, especially in Latin American or African history.

Associate Professor Peter C. Perdue was promoted to full Professor, and Assistant Professor Christian Appy was promoted to Associate Professor, effective July 1, 1994.

INSTITUTE COMMITTEES AND SERVICE
Assistant Professor Robin Kilson, along with STS Assistant Professor Evelynn Hammonds, conceived and organized the international conference *Black Women in the Academy: Defending Our Name, 1894-1994*. Over 2,000 participants attended this three-day examination and celebration of black female scholars. The conference was funded by numerous major foundations, and was so successful that plans to repeat this event are already underway at Spelman College.

Associate Professor Arthur Kaledin chaired the Disabilities Advisory Committee and served on the Committee on Curricula. Assistant Professor Anne McCants chaired the Truman Scholarship Selection Committee. Professor Pauline Maier served on the Institute Committee on Privacy, the Killian Prize Committee, and the Ad Hoc Faculty Committee on the Closing of CMRAE. Professor Perdue served on the Academic Computing Committee. Professor and Associate Dean Harriet Ritvo served on the Institute Committee on Animal Care, the Committee on Faculty Policy, and chaired the HASS-D Overview Committee and Review Committee.

EDUCATION
A number of faculty [Appy, Maier, Mazlish, Perdue, Ritvo] participated in the joint Ph.D. program in the History and Social Study of Science and Technology, by teaching graduate seminars, supervising general exams, or conducting tutorials, and Professor Dower advised advanced graduate students in Japanese history at Harvard.

We are quite proud of our History majors, who take the road less traveled. This year, an unusual number of students completed senior theses in history, and, most impressively, four of them went on to advanced study in humanistic fields: Naghmeh Sohrabi, who studied propaganda in Iran during the Iran-Iraq war, will study for an advanced degree in history at Harvard; Yan Zelener, who wrote about the development of the Hellenistic ruler cult, will study ancient history at Columbia; Alfred Eaton, who studied the growth of the masonic lodge in Mormon Nauvoo, will attend Dallas Theological Seminary; and Jeffrey Strickland, a double-major in biology, wrote on Greek physicians in the Roman empire and will attend medical school at the University of Pennsylvania. In addition, Amani Harrison wrote about history and literature related to the experiences of Korean women, and Hans Godfrey wrote on student government at MIT during the 1960s. History concentrators numbered 138. There were 10 history majors, 19 history minors, and 10 minors in East Asian studies.

The most popular subjects were: 21H522 Japan in the Age of the Samurai (30); 21H913 The Last Hundred Years (in world history) (40); 21H921J Ideas of the World Order (65); 21H301 The Ancient World: Greece (68); 21H104J Riots Strikes, and Conspiracies in American History (33); 21H425 War, State, and Society in Modern Europe (36); 21H546 World War II in Asia (30); 21H302 The Ancient World: Rome (74); 21H161 Introduction to Black Studies (36); and 21H102 Emergence of Modern America (31).

Three faculty led freshman advisor seminars on: History of Cosmology (McCants); Biography (Watson); and Conflict and Peace (Khoury). Professors Appy, McCants, Ritvo, Watson, and Perdue supervised UROP projects.
OTHER ACTIVITIES
Associate Professor Douglas Forsyth directed the Kenan Sahin lecture series during its third year with a series of talks on "Post-Cold War Transitions". Professor Mazlish again jointly ran the History and Literature Workshop series, and Dean Khoury directed the Bustani Middle East Seminar. During IAP, Professor Appy gave a course for credit, American Films of the Cold War, and participated in a debate: "Was Vietnam a Working-Class War?".

Professor Pauline Maier served as Acting Head during the fall term while Associate Professor Peter C. Perdue was on leave.

PETER C. PERDUE
1993-94 was an active and successful year for the Literature Faculty, during which three faculty members were promoted: Assistant Professor Mary Fuller to Associate Professor, Associate Professor Henry Jenkins to Associate Professor with tenure, and Associate Professor John Hildebidle to Professor. In addition, Professor Jenkins was selected as the Class of 1942 Career Development Professor for a term of three years.

**Academic Program and Student Enrollment:**
During the past year, 893 students enrolled in Literature subjects, 8 were registered as Literature majors, 25 as minors, and 108 as concentrators in Literature for the HASS requirement. The addition of Dr. Janet Murray’s subject 21L489J, The Structure and Interpretation of Non-Linear Interactive Narrative complements 21L178, Technologies of Humanism, introduced last year. Both of these subjects use interactive technologies developed at MIT to study literary and dramatic works in new ways. This year 21L178 focussed on Shakespeare in Performance, using the Shakespeare Interactive Archive’s system for linking electronic text to filmed performances. 21L489J explores the emerging genre of interactive stories and novels. In these subjects, students also use the software to create their own multimedia interpretive essays and interactive fictions. This year as well, the Film and Media Program, directed by Professor Henry Jenkins, took a significant step in offering a Major Departure for the first time.

**Research and Publication:**
Professor Peter Donaldson continues work on Shakespearean film adaptations and the implications of new technologies for the study and editing of Shakespeare, and completed the second in a series of computer-directed interpretive essays, "Books in Bits: Images of Print in Shakespeare Film from Olivier's *Henry V* to Greenaway's *Prospero's Books." Professor David Halperin published several essays, is working on a book on Michel Foucault, and published the first issue of *GLQ: A Journal of Lesbian and Gay Studies*, of which he is co-editor. Professor Hildebidle published poems, essays, critical studies and short fiction in *Eire-Ireland, Thema, Other Arts* and in several collections. Professor Ruth Perry continues work on her study of the family in the eighteenth century novel, her reviewing for *The Women’s Review of Books* and other publications, and published essays in *Women’s Writing in the Early Modern Period* and in *History, Gender and Eighteenth Century Literature*, edited by Elizabeth Fox Tobin. Professor Stephen Tapscott published articles in collections on Walt Whitman and William Carlos Williams and completed work on his anthology of Latin American poetry. Professor Irene Tayler continues research on "Veiled Woman: the Evolution of an Image," and has published several reviews. Professor Fuller’s book on Renaissance narratives of discovery has been accepted for publication by Cambridge University Press. Assistant Professor Louis Galdieri is completing a study of Thomas More and Renaissance historiography for publication. Professor David Thorburn published interpretive essays on television narrative and continues his study of prime-time television. Professor Jenkins published essays in *Film Quarterly* and *Quarterly Review of Film and Video* and completed six other essays and two co-authored books, one on Classical American Screen Comedy and one on the audiences of television science fiction series, both to be published by Routledge.

**Conferences and Invited Addresses:**
Members of the faculty have also presented their work at a number of conferences including meetings of the Shakespeare Association of America, Center for Literary and Cultural Studies, Harvard University, Society for Cinema Studies, The American Studies Association, The Modern Language Association, The Jane Austen Society, The Northeast Modern Language Association, The Berkshire Conference on the History of Women, The New England American Studies Conference, The Sixteenth Century Studies Conference, the Academia Latinitati Fovendae (Antwerp), Consoling Passions: Feminism and Television Conference. They have also delivered public lectures and presentations at the Sorbonne, the University of London, the National Film Theatre (London), Drake University, Hampshire College, Cornell University, Wellesley College, Concordia University, University of New Hampshire, Bowdoin College, NYU, Notre Dame, Loyola University (Chicago), University of Massachusetts, Amherst, Pitzer College (Claremont, California), at a number of universities in Australia (Sydney, Monash, Queensland), Austria (Vienna, Salzburg), Hungary (Budapest), and Poland (Jagelonian University, Krakow).

**Service, Grants and Awards:**
The Shakespeare Interactive Archive, headed by Professor Donaldson, Visiting Professor Larry Friedlander and Dr. Janet H. Murray, Director of the Laboratory for Advanced Technology in the Humanities received its third major grant from the National Endowment for the Humanities for the second phase of a multimedia research archive linking electronic texts of Shakespeare plays to filmed performances, artwork, photographs of important productions and photogfacsimiles of early editions. The grant, from the Research Division of NEH, provides $250,000 in direct support and $100,000 in federal matching funds. Professor Donaldson also began a five-year appointment as the first Ann Fetter Freidlaender Professor of the Humanities. Professor Halperin was in residence at Cornell as Fellow of the Society for the Humanities, as Visiting Professor at the University of Queensland, Australia,
and Visiting Fellow at the University of Sydney, and received the Michael Lynch Service Award from the Gay and Lesbian Caucus of the Modern Language Association. Professor Tapscott served as poet in residence at Cornell University. Professor Thorburn completed his term as Director of the Cultural Studies Project at MIT. Professor Perry served as Chair of the Steering Committee of the Graduate Consortium of Women's Studies at Radcliffe, and as a member of the editorial board of PMLA. Professor Alvin Kibel serves as chair of the Library of Congress fin de siecle conference. Professor Hildebidle was awarded a Fulbright Fellowship for study in Ireland.

Personnel:
In November, 1993, Janet Sahlstrom was appointed Administrative Officer in Literature, replacing Eve Diana who returned to the Chemistry Department. In the Fall Term, Professor Larry Friedlander of Stanford University held an appointment as Visiting Professor of Literature and Media Arts, an appointment held jointly with the Media Arts and Sciences Section of the Media Laboratory. Several members of the regular faculty were promoted, effective July 1, 1994. Associate Professor Theoharis C. Theoharis' appointment terminated this year. James C. Buzard, currently Assistant Professor of English at Fordham University, will be appointed as Assistant Professor of Literature beginning July 1, 1994.

Affirmative Action:
While this year's faculty search did not result in the hiring of a woman or minority faculty member, the goal of adding at least one minority faculty member and at least one woman faculty member in the next several years is reasonable, and extensive efforts to accomplish it will be made through searches and active recruiting.

PETER S. DONALDSON
Academic Year 1993-94 has been the Year of the Arts at MIT. In significant ways it has marked a coming of age for Music and Theater Arts. Alan Brody, Professor of Theater Arts and Section Head, was designated the Class of '60 Fellow through FY 1995, and John Harbison, Professor of Music, was awarded the prestigious Killian Award by his colleagues at the Institute, the first member of Humanities to receive this honor. The Arts were also the focus of 1994’s Tech Day which featured presentations that included Professor Harbison, Senior Lecturer in Music John Oliver, and Professor of Media Arts and Sciences Barry Vercoe from Music and Professor Brody, as well as Lecturers Michael Ouellette, Kim Mancuso and Kermit Dunkelberg from Theater Arts. This year’s Windows on MIT series also focused on the Arts and included a unique program of faculty compositions performed by both faculty and students.

With support from members of the Council for the Arts at MIT and a commitment by the Institute, two major facilities came on-line. During the fall, eight state-of-the-art music practice rooms were opened on the second floor of building 4. Rooms are now available to members of Section Performance Groups 24 hours per day, and reaction from students, faculty and staff alike has been overwhelmingly positive. Renovations to the former Rinaldi Tile Building (E33) on Carleton Street has made possible the consolidation of the technical staff of Theater Arts, a move that will provide stability for this peripatetic group and opportunity for far more interaction between students and teaching staff than ever before.

Another important goal was achieved this year with the amalgamation of the two separate administrative staffs of music and theater into one central location in Building 14. This has allowed us to continue to grow and support new endeavors without adding additional staff.

One such new endeavor has been the formation of a Balinese gamelan under the direction of Evan Ziporyn, Assistant Professor of Music. Gamelan Galak Tika gave its premier performance in December to a packed Killian Hall and joined Gamelan Sekar Jaya for demonstrations and performances in the Cube during April. Another collaborative event was the Shakespeare Ensemble's performance of Master/Mistress of My Passion with music composed by the multi-talented Adrian Childs, a Class of '94 music/math double major. A very special opportunity allowed three MIT student pianists to join world-renowned cellist Yo-Yo Ma in performance of a reading of Professor Harbison’s new Cello Concerto here on campus before its premiere in Symphony Hall.

Enrollments reached their highest total ever with 1711 students taking music or theater subjects for credit. Seven music majors and two theater major departures were among the graduates this year. Three members of this group of nine students captured the Sudler and Wiesner prizes for artistic excellence and achievement.

The academic programs continued to explore new ways to engage student talent and interest. Some 225 students from the MIT Symphony Orchestra and Concert Choir came together under the baton of Senior Lecturer Oliver to present the first joint effort of these two large ensembles in a performance of the Verdi Requiem.

Throughout 1993-94 the Section continued to pursue its affirmative action commitments to increase the number of women and minorities on the staff and the number of students taking courses in different cultures. The year saw Brenda Cotto-Escalera, who was recruited under the Provost's Initiative for Women and Minorities, complete the first of her two years as an Artist-in-Residence in Theater Arts. Ms. Cotto-Escalera, in collaboration with Maria Gonzales-Aguilar, Lecturer in the Foreign Languages and Literature Section, developed a course in Spanish that brought student-written-and-performed puppet theater to elementary and secondary schools in Cambridge and Boston. In addition to the creation of the Balinese gamelan ensemble in the fall term, during the IAP and spring terms Theater Arts produced the Bengali play, Procession, directed by Sameera Iyengar '93; Suenos Infinitos, an original theater piece developed in collaboration with guest artists Rosa Luisa Marquez and the Peruvian theater company, Yuyachkani; David Henry Hwang's FOB; Zero Eleven, an original play by Serbian student, Ivana Komarcevic, '96; and a revival of Professor Brody's production of Vinie Burrows in Sister! Sister! in conjunction with the Conference of Black Women in the Academy.

The faculty has had a distinguished year of professional activity, as well. Professor Harbison continued to enhance his breathtaking career with acclaimed performances of his work (including world premieres) by the Pittsburgh, San Francisco, Minnesota, and Boston Symphony Orchestras, and the Guarneri and Lydian String Quartets. He received new commissions from World-Wide Premieres and Commissioning Fund and from pianist Robert Levin. The academic year also saw the publication of his Piano Sonata No. 1, Piano Quintet, and Symphony No. 2. Professor of Music Marcus Thompson appeared in eight chamber music festivals from Alaska to Maine, California to Florida. He was guest soloist with the Mozart Orchestra.
School of Humanities and Social Science

of Hamburg and performed the music of Robert Schumann in an all-day marathon concert broadcast live from the Odeon Theater in Amsterdam by Netherlands Radio. Associate Professor of Music Peter Child saw performances of his work by Parnassus and the New England Conservatory, and Senior Lecturer in Music Edward Cohen's Piano Trio was premiered by the Raphael Trio by whom it was commissioned. Professor Brody's play, The Company of Angels, had its second professional production at the T. Schreiber studio in New York City and, as a result, will have another production at Theater Emory in Atlanta next season. Professor Brody was also the keynote speaker at the 1994 Phi Beta Kappa initiation ceremony.

The one sad note in the year came with the necessary phasing out of the Dance Program in response to the Provost's call for budget cuts.

Professor Ziporyn was promoted to Associate Professor without tenure; Janet Sonenberg, Assistant Professor of Theater Arts, was reappointed; and contracts were renewed for full-time Lecturer Ouellette, and Lecturers in Music Pamela Ambush, George Ruckert, and Elena Ruehr. We also note with pleasure and appreciation that Lecturer in Music John Corley, founder and director of MIT's Concert Band and conductor of many MIT Commencement Orchestras celebrated his 45th anniversary at the Institute during this academic year.
The Program in Writing and Humanistic Studies is an interdisciplinary program concerned with writing as a means of communication of ideas, a means of creative expression, and a vehicle for exploring the cultural context of science and technology. Each year, approximately 900 undergraduates enroll in our subjects. Some subjects satisfy either Phase One or Phase Two of the Institute Writing Requirement. The cooperative writing subjects for both undergraduates and graduate students, within the various engineering departments, continue to hold their enrollments. The summer session course 21.10s Communicating Technical Information was again popular with many students from industries throughout the world.

In addition to its curriculum, the program offers a number of cultural and literary activities to the MIT community. Ben Okri, winner of the 1991 Booker Prize, was here for a week in April as writer-in-residence, during which he gave a public reading, met separately with faculty and students, and gave a couple of master classes in writing. We invited Salman Rushdie to MIT to read in our Writers Series and helped with the complex logistics of organizing his trip. As part of the necessary secrecy, we arranged for Susan Sontag to serve as his cover. The program also played a role in bestowing an honorary visiting professorship on Mr. Rushdie. The Pulitzer prize-winning poet W.S. Merwin read in the Poetry at MIT series.

In research and writing, Professor Kenneth Manning continues his project on "Blacks in American Medicine, 1860-1980". Professor James Paradis continues his work on Samuel Butler. Professor Elzbieta Ettinger Chodakowska continues her biography of Hannah Arendt. Associate Professor Rosalind Williams continues her work on the cultural history of technology. Assistant Professor Susanne Klingenstein has almost finished her new book on Jewish academics in America in the 1930s through 1960s. Senior Lecturer Edward Barrett has been reappointed as senior lecturer and has done a very good job with his first year working with the new Writing Initiative. Professor Alan Lightman has finished a new novel, Good Benito, to be published in early 1995. Professor Anita Desai has finished a new novel, Journey to Ithaca, to be published in Spring 1995.

Susanne Martin has finished her first year as Program Administrative Officer and done a superb job.

We made a vigorous attempt to hire two black writers, Gayle Pemberton at Princeton and Gerald Early at Washington University. In the case of Early, the negotiations got quite far along, but Early, in the end, felt that he could not leave the Afro-American studies program that he had started at Washington University. We will continue our efforts to appoint outstanding black writers and scholars, especially black women.

In 1993-1994, we had 62 percent women on our total staff and 56 percent women on our professorial staff. We have one member of an underrepresented minority on our professorial staff.

ALAN LIGHTMAN
INTRODUCTION
The Department of Linguistics and Philosophy consists of two sections, twenty-four faculty members (five of them jointly appointed), sixty graduate students, around twenty visiting scientists and scholars, and a staff of six. Each section operates with a large measure of independence; yet between them there is a significant overlap of intellectual interests in education and research, both among the faculty, the graduate students, and the visitors.

RESEARCH: LINGUISTICS
The linguists continue to pursue an account of natural language in terms of principles of computational economy. The 'minimalist' program for linguistic theory, 'zero' syntax, optimality theory, and the theory of distributed morphology offer somewhat different suggestions for the course that the pursuit might follow, and for the reduction of the conceptual apparatus of linguistic theory to virtual conceptual necessity. These ideas continue to be explored, developed, and challenged in research on the syntax, semantics, morphology, phonology, and on the interfaces of these modules of the grammar of natural language by MIT graduate students, faculty, and visitors.

A recent innovation in the linguistic research program is the MEG (magnetic encephalographic) studies of phonetic perception being carried out by Associate Professor Alec Marantz and students (both graduate and undergraduates). This research, undertaken in the context of the NSF-supported joint Linguistics-Cognitive Science program ('Language: Acquisition and Computation'), is supported by the Office of the Provost.

RESEARCH: PHILOSOPHY
There are a number of topics being pursued in current research in philosophy, including the following: Russell's theory of descriptions; deflationary theories of meaning and reference; the logic of provability; quantified modal logic; foundations of game theory; associative democracy; freedom of expression; moral objectivity; consciousness; holism; and Wittgenstein's later philosophy.

PUBLICATIONS
As in the past, the faculty on both sides of the Department published a large number of journal articles, chapters in books and reviews. In addition, the following books appeared during the past year: Professor George Boolos's Logic of Provability, Institute Professor Noam Chomsky's Language and Thought, Associate Professor Michael Hardimon's Hegel and Social Philosophy: The Project of Reconciliation, Professor Michael Kenstowicz's Phonology in Generative Grammar; and Professor Irving Singer's Pursuit of Love.

In the fall, there appeared a festschrift for Emeritus Professor of Philosophy Sylvain Bromberger (The View from Building 20: Essays in Linguistics in Honor of Sylvain Bromberger), edited for the MIT Press by Professors Kenneth Hale and Samuel Jay Keyser, with essays by ten of Professor Bromberger's linguistics colleagues at MIT. The royalties from the book flow into a department account for the support of graduate students in linguistics.

Professor Chomsky is, appropriately, the subject of the first entry in Routledge's new series, "Critical Assessments of Leading Linguists": Noam Chomsky: Critical Assessments (eight volumes), Carlos Otero, editor.

HONORS AND AWARDS
Professor Kenneth Hale is currently President of the Linguistic Society of America and Chair. Work on local, or endangered languages, a research initiative of the linguistics program and a central concern of both Professor Hale and Professor Wayne O'Neil, received welcome support from the Office of the Provost. Professor George Boolos is currently Vice President of the Association for Symbolic Logic. Professor Ned Block's work on the philosophy of mind was the subject of a conference held at the University of Barcelona. Professor Hardimon spent the year as a fellow in the Harvard Program in Ethics and the Professions, working on the topic of role obligations.
The 1993-94 academic year was one of continued distinction for the MIT Political Science Department. The department recruited new faculty talent engaged in extensive faculty research and teaching, and placed its graduates in leading institutions around the world. Our greatest challenge continues to be the need to adapt our teaching and research rapidly to changing global politics.

RECRUITMENT

The department was again successful in hiring new junior faculty. Melissa Nobles was recruited from Yale University, where she will soon complete her dissertation on race and politics in Brazil. She will add depth to our offerings in comparative politics, political development, and social movements. Her appointment increases the number of our African-American faculty. Frederic Schaffer, from the University of California at Berkeley, is also completing a highly-regarded dissertation in the area of language and politics in Senegal. Both Ms. Nobles and Mr. Schaffer will join the faculty as assistant professors in 1994-95. In addition, the department offered its third annual minority postdoctoral fellowship to Dr. Sandra Suarez-Lasa of Yale University. This fellowship was initiated with (and is supported entirely by) department resources. We continue to remain committed as a department to hiring minority and women faculty.

PUBLICATIONS

The faculty continues to produce significant scholarship. (The list is too long to include articles and monographs; therefore only books are listed.) Professor Nazli Choucri authored Population and Political Economy: Dilemmas of Security in Egypt, Routledge, forthcoming. Assistant Professor Zhiyuan Cui is co-editor of China’s Reform: Toward Institutional Innovation, Oxford University Press, forthcoming. Associate Professor Jonathan A. Fox co-authored "Introduction and a chapter entitled "Targeting the Poorest: The Role of the National Indigenous Institute in Mexico’s National Solidarity Program," in a book he co-edited, Transforming State-Society Relations in Mexico: The National Solidarity Strategy, University of California, San Diego, (USCD) Center for US-Mexican Studies. Professor Richard J. Samuels’ new book, Rich Nation, Strong Army: National Security and the Technological Transformation of Japan, was published by Cornell University Press. Professor Myron Weiner was editor (with Ali Banerazizi) of The Politics of Social Transformation in Afghanistan, Iran, and Pakistan, Syracuse University Press.
TEACHING

The department’s teaching program has developed new subjects as well. Professor Suzanne Berger has prepared a seminar on Domestic Politics of Trade and Integration. Professor Fox developed an undergraduate seminar on Mexico’s Presidential elections, as well as a new Hass-D subject, Introduction to Latin American Studies. Assistant Professor Daniel T. Kryder has revived subjects which have not been taught in several years: Social Movements and American Politics, The President, American Political Development, and Politics of Race and Ethnicity in America. In addition, the undergraduate program is getting a boost from the development of an "MIT in Washington" internship program, scheduled for inauguration in 1994-95, under the direction of Associate Professor Charles Stewart III. Professor Weiner created a new subject, Political Development: Trends, Issues, Theories, and Concepts.

HONORS

Several honors and grants were awarded to the faculty this year. Professor Berger received the "Mentor of Distinction" Award from the American Political Science Association (APSA), and was listed among 170 American political scientists in the Directory of American Political Science. Professor Choucri received funding from the United Nations Population Fund, "Population and the Global Environment" (a two-year project); the United Nations Environment Programme, Consortium on Technology, Environment, and Sustainable Development (a three-year project). Professor Fox was awarded an international affairs fellowship by the Council on Foreign Relations. Professor Charles F. Sabel received the Graduate Student Council Award for outstanding teaching. Professor Stewart received an award by the Politics and History Section of APSA for the best article or essay written in 1993 or 1994, for "Stacking the Senate, Changing the Nation," Studies in American Political Development. Professor Weiner received a grant from the Japan Foundation Center for Global Partner for a project, US-Japan Symposium on Japan and US Immigration, Refugees and Citizenship Policies.

OUTSIDE ACTIVITY

Faculty continue to be very active in professional associations and other forms of public service. Professor Berger served on the boards of the National Academy of Science Committee on Japan; the German-American Academic Council; and Fundacion Juan March Scientific Committee. Professor Choucri was a member of the editorial board of International Political Science Review, and of Business in the Contemporary World, as well as on the fellowships review board of the United States Institute for Peace. She was also special advisor to the Administrator of the United Nations Development Program, and a member of the project team for USAID program in Pakistan, Project on Science, Technology, and
Development. Professor Joshua Cohen was associate editor at Philosophy and Public Affairs, and a member of the editorial board of Politics and Society. Professor Fox was a member of the International Predissertation Fellowship Committee of the Social Science Research Council, and a consultant to the World Bank, Participation Learning Group. Professor Willard R. Johnson presided over the Board of the Fund for Democratic Elections in South Africa. They raised over $900,000 in the US to assist Nelson Mandela and other democratic candidates to compete in the elections. He also made numerous local television show appearances discussing African issues. Professor Kenneth A. Oye was a member of the editorial Board of World Politics. Professor Barry Posen served on the editorial boards of International Security and Security Studies. Professor Samuels was a member of the National Research Council Aircraft Project Study Team; he was selected to be a member of the Abe Program Fellowship Committee of the Social Science Research Council, served on the Dean's Advisory Committee to Review Asian Studies Program at New York University, and is vice-chairman of the Committee on Japan of the National Research Council. Professor Samuels also served on the Panel on Multinational Corporations of the US Congressional Office of Technology Assessment. Professor Sapolsky was a member of the Secretary of Energy Advisory Task Force on Alternative Futures for the Department of Energy's National Laboratories. Professor Eugene B. Skolnikoff served on National Academy of Science panels, and was advisor to International Climate Change Study. Professor James M. Snyder, Jr. joined the editorial board of Economics and Politics. Associate Professor Stephen Van Evera served on the editorial boards of International Security, Security Studies, and Orbis. Professor Weiner gave a briefing to Indian Ambassador designate Steven Solarz at the Asia Society. He was also director of the Joint German-American Project on Migration and Refugees Policies for the American Academy of Arts and Sciences, and was a member of the Board of Trustees for the Fund for Peace and of the Editorial Board of Asian Survey and Third World Quarterly.

INSTITUTE SERVICE

Within the Institute and the department, Professor Berger has done research on trade pressures and national models of capitalism, supported by the Institute's Industrial Performance Center. She was also a member of the faculty committee of the Industrial Summit, and the Presidential Task Force on Industrial Linkages. Professor Donald L.M. Blackmer was on the Committee on Graduate School Policy, the steering committee of Technology and Culture Seminar and the Truman Scholarship steering committee. Professor Choucri was head of the Middle East Program, and a member of the Faculty Advisory Committee of the Sea Grant Program. She was also chair of the Committee of MIT Faculty Seminar on Global Environment and Sustainable Development, editor of the MIT Press Series on Global Environmental Accords, chair of the Faculty Committee for the Consortium on Global Environment
and Sustainable Development, and member of the editorial board of the MIT Faculty Newsletter. Professor Cohen again served as a member of MIT Press' faculty board and the Oversight Committee for the Women's Studies Program. Professor Fox was a member of the institute's IAP Committee. Professor Johnson was a member of the Corporate Joint Advisory Committee, the Martin Luther King, Jr. Celebration Committee, and the School of Humanities and Social Science (SHSS) Equal Opportunity Committee. Professor Oye was chair of the SHSS Committee on Regional Studies Minors, and a member of the MIT Council on Global Environment. He was also director of the Center for International Studies, co-director of Seminar XXI Program with Professors Posen and Weiner, and housemaster of East Campus Alumni House. Professors Posen and George W. Rathjens were members of the Committee on ROTC.

Professor Samuels was head of the department, and director of the MIT Japan Program. Professor Skolnikoff was a member of the Institute Committee Federation, and the Advisory Committee to President on Federal Relations. He was also co-chairman of the MIT Seminar for Congressional Staff. Professor Stewart was a member of the Institute Committee on Undergraduate Program, and the Committee to review the Humanities, Arts, and Social Science Distribution Requirement, as well as housemaster of McCormick Hall. Professor Weiner was a member of the MIT Library Committee, and co-chair of the Joint Harvard-MIT Seminar on Political Development (JOSPOD).

PLACEMENT

This past year our graduating doctoral students have accepted positions at leading universities throughout the world, including Johns Hopkins University, Harvard University, Brown University, Rutgers University, and Princeton University. Others went into government positions at the Pentagon, the Center for Naval Analysis, and the House of Representatives; and, in the private sector, the Carnegie Corporation.

RICHARD J. SAMUELS
1993-94 was a year of transition and adjustment for the Program in Science, Technology, and Society (STS) as faculty members worked to fine-tune graduate and undergraduate programs and to find resources to support the former activity.

DOCTORAL PROGRAM

In its sixth year, the Doctoral Program in the History and Social Study of Science and Technology (a collaborative venture of STS, the History Faculty, and the Anthropology/Archeology Program) continued to develop in a satisfactory way. At the Annual Meeting of the MIT Corporation on October 1, 1993, the Corporation voted to approve the Doctoral Program on a permanent basis. Present and incoming students received a variety of grants, including Dibner, Javits, Mellon, National Science Foundation (NSF), and National Science and Engineering Research Council (Canadian government) fellowships. The Program received 84 applications for the 1994-95 academic year. Five of the students were offered admission to the Doctoral Program. Important roles in the Program were played by Professors Kenneth Keniston (Director of Graduate Studies) of STS, Jed Buchwald (Director of the Dibner Institute and member of the STS faculty), James Howe of the Anthropology/Archeology Program, and Associate Professor Peter Perdue of the History Faculty, all of whom were members of the Doctoral Program Steering Committee. As Director of the STS Program, Professor Merritt Roe Smith also served on the Doctoral Program Steering Committee.

PROJECTS, GRANTS, AND INITIATIVES

The STS Program received $784,728 in grants for new and continuing research projects during the 1993-94 academic year.

Integrating the American Past: A New Narrative History of the United States

Based on a Sloan Foundation grant that will total $1.754 million over six years, the project aims at producing a one volume narrative history of the United States that addresses processes of technological and scientific change and places them at the core rather than the periphery of the American experience. The resulting study is intended for the general public as well as for introductory college level survey courses in American history. The project is headed by Professor Smith and includes Professors Pauline Maier (MIT), Alex Keyssar (Duke), and Daniel Kevles (California Institute of Technology) as primary authors. Entering its third year, the group has completed a detailed outline of the text and drafted an accompanying prospectus.

Humanities and the Environment

In the second year of a three year project supported by the John D. and Catherine T. MacArthur Foundation, Professor Emeritus Leo Marx organized a series of nine well-attended workshops held at MIT on the theme of "Modernity and the Protection of the Environment." The sessions were attended by approximately twenty-five faculty and graduate student members. The project also provided full support for two graduate students from the Doctoral Program in the History and Social Study of Science and Technology. For the third and final year of the project, the topic of the workshop series is "Environmental Movements." The workshops will examine the makeup, outlook and history of a number of recent environmental movements both in the developing and the industrialized nations.

History and Social Study of the Life Sciences

The fourth year of the Mellon Project focused on "Institutional and Disciplinary Contexts of the Life Sciences" and was headed by Professor Evelyn Fox Keller. In addition to a well-attended workshop on the year’s theme, the project also supported the work of three postdoctoral fellows who helped plan and also participated in the workshop. An international field of 16 candidates applied for the three available fellowship positions this year. Those appointed by the Mellon Selection Committee (Professors Keller, Keniston, and Charles Weiner and Associate Professor Lily Kay ) are Dr. Debora Karmat-Lang (Hebrew University), Dr. Karen Rader (Indiana University), and Dr. Nadine Weidman (Cornell University). Professor Kay will assume leadership of 1994-95’s workshop on "From Molecular Power to Biological Wisdom: Challenges and Needs in Historical and Social Studies of Twentieth Century Life Sciences."

US-Soviet Science Workshop

Funded by the MacArthur Foundation, this project completed its fourth year under the leadership of Professor Loren Graham. The final workshop was held this year in St. Petersburg in June 1994 on "New Approaches to the History and Social Study of Science and Technology." One of the main subjects of discussion at this workshop was a comparison of Russian and American scholarship in the history of science and technology.
Information and the Transformation of Molecular Biology

This year, Professor Kay received funding from the Ethical, Legal and Social Issues of the Human Genome Research project at the National Institutes of Health. Professor Kay's project involves archival research leading to a book tentatively titled Code, Program, Text: Information and the Transformation of Molecular Biology. The book focuses on the years 1953-1973, when researchers unravelled salient mechanisms of DNA function, representing it as information transfer. The aim of the project is to reconstruct a critical history of this time period. Professor Kay was assisted this year by a current and an incoming graduate student.

The Dibner Institute for the History of Science and Technology

In the fall of 1993 the Dibner Institute inaugurated its fellowship program, which each year brings scholars from around the world to the Dibner to pursue their work under its auspices. Nineteen fellows were selected for 1994-95 from over a hundred applications. In addition to its regular series of colloquia and lectures, the Dibner Institute organized two conferences for the spring of 1994. One concentrated on the history of entropy, the other on Babylonian astronomy and divination. Two conferences will be held in spring, 1995 and one symposium in fall, 1994. Colloquia and lectures will take place weekly.

SPECIAL EVENTS

1993 Siegel Prize in Science, Technology and Society

Awarded for the best student paper on the historical, social, and policy implications of science and technology, the Siegel Prize is open to graduate as well as undergraduate members of the MIT community and consists of an award of $2,000 as well as publication of the winning essay in the STS Working Papers series. This year's winner, chosen from a field of eleven entries, was Mr. Russell Olwell of STS for a paper entitled "Politics, Physics and the Cold War: The Two Exiles of David Bohm." Two papers were awarded Honorable Mention: Mr. Greg Clancey, STS, for his paper "The Balloon Frame Myth," and Mr. David Mindell, STS, for his paper "The Clanger of the Blacksmith's Fray: Technology, War and Experience Aboard the USS Monitor." Mindell's paper has been accepted for publication in the journal, Technology and Culture; Clancey's paper is currently being reviewed by the same journal. Applications for the third year of the award have been received; the winner of the prize will be announced in the fall.

EDUCATIONAL ACTIVITIES

The STS Program's educational work continued at both the undergraduate and the graduate levels. In all, the Program offered 32 undergraduate subjects and 36 graduate subjects during the past academic year. Undergraduate enrollments totaled 420. STS offered five new undergraduate subjects: "The History of Epidemic Diseases: From Plague to AIDS" (Assistant Professor Evelyn Hammonds), "History of Developmental Biology" (Professor Keller), "Film as Ethnography and as Cultural Critique" (Professor Michael Fischer), "Women and Health in America" (Professor Hammonds), and "Gender and Science" (Professor Keller). On the graduate level, six new seminars were introduced: "Aspects of 19th Century Physics" (Professor Buchwald), "Computers and Organisms" (Professors Hammonds and Keller), "Film as Ethnography and as Cultural Critique" (Professor Fischer), "Ethnographic Research Seminar" (Professor Fischer), "Organization of Knowledge in American Science and Technology" (Associate Professor Deborah Fitzgerald), and "Rethinking Culture and Social Theory" (Professor Fischer). During the 1993-94 academic year there were 3 majors, 6 minors, and 66 concentrators (classes of 1994-1996) in STS.

COLOQUIA

The STS Colloquium has become a core activity of the Doctoral Program in the History and Social Study of Science and Technology. In its fourth year and headed by Professor Merritt Roe Smith, the colloquium brought 24 speakers to MIT from such institutions as Brown University, Johns Hopkins University, Harvard University, New School for Social Research, and Stanford University. Professor Smith, working with an advisory group of doctoral students and an STS faculty member, Professor Fischer, will continue to organize the colloquia next year.

CONTINUING ACTIVITIES

The Program continued a number of activities that had been initiated in earlier years. In the Student Lunch Workshops graduate students meet frequently to discuss their ongoing research and current literature in the history and social study of science and technology. The STS Newsletter, ably produced by staff member Mr. Graham Ramsay, continued with articles of general interest followed by news and notes on STS faculty, staff, and students. The STS Working Papers, under the editorship of Professor Keniston, continue to provide a means of disseminating early versions of work in progress.

KNIGHT SCIENCE JOURNALISM FELLOWSHIP PROGRAM

Now entering its twelfth year, the Knight Fellowships continue to attract science journalists from around the world to MIT to learn more about the research and innovation they cover. During their nine months on campus, they attend seminars, classes
and workshops devoted to science and technology studies. The eleventh year, organized by Mr. David G. Ansley (Acting Director), included eleven Fellows from the United States, Japan, Germany and Australia. Special events included a large public panel discussion where prominent scientists and journalists aired their differences; a seminar with NIH Director Harold Varmus; and two days of hands-on work in a genetics laboratory. Senior Research Associate Victor McElheny (Director of the Knight Science Journalism Program) completed a 15-month leave to write a biography of Edwin Land and resumes his position September 1.

FACULTY ACTIVITIES
Professor Buchwald serves as Director of the Dibner Institute for the History of Science and Technology. He published a book entitled The Creation of Scientific Effects, was a contributing editor for The Collected Papers of Albert Einstein, and published four other articles during the past year. He gave talks at Stanford University, New York Academy of Sciences, Max Planck Institute, Germany, International Meeting in Saragosa, Spain, Van Leer Institute, Jerusalem, and University of South Carolina at Columbia. He co-organized with Professor Keller an international conference on "Entropy" at the Dibner Institute, April 1994. He attended ten conferences during the past year; he was a commentator at four of these conferences and a speaker at one conference. Professor Fischer published five articles during the past year and continues to pursue research on science autobiographies and filmic judgment and cultural critique. Professor Fischer served on the Doctoral Program Admissions Committee, the Graduate Program Steering Committee, the Environment Workshop Planning Committee, and the Cultural Studies Steering Committee. Professor Fitzgerald continued to serve on the Editorial Board of The M.I.T. Press, served on the HASS-D Overview Committee, and chaired a session at an IAP conference on technology and Labor. Her research on the corporatization of American agriculture during the 1920s and 1930s has resulted in a book manuscript Yeoman No More: The Industrialization of American Agriculture. In addition to giving the keynote address at the National Agricultural Technology Conference in May, she also gave talks at Harvard, Yale, and the University of Minnesota, was a panelist for the National Endowment for Humanities, and attended four other conferences. She was elected to the Executive Council, Society for the History of Technology, and was nominated to serve on a two person Program Committee for the History of Science Society for 1995.

Professor Graham published The Ghost of the Executed Engineer: Technology and the Fall of the Soviet Union which received several honors: named by the New York Times Book Review as "One of the Notable Books of 1993" and by the Association of American Publishers as "Honorable Mention in Engineering for 1993." Forthcoming: "Technology and the Fall of the Soviet Union," Proceedings, American Philosophical Society, and Review of Roald Sagdeev, The Making of a Soviet Scientist. He has three major works in progress: Bibliography of the History of Russian and Soviet Science, Powers of the Air and His Island, and Democracy and Science in Russia and the Soviet Union. He continued to head two projects: the MacArthur-funded project on the social and political dimensions of science and technology in the U.S.; and the Sloan-funded project on creating an archive on recent changes in the organization of Russian science. He was awarded a grant by NEH for a three-year project on "Science and Democracy in Russia and the Soviet Union." In addition to giving five lectures, he attended a meeting in Moscow on helping Russian science, chaired a meeting of the MacArthur Foundation in Moscow on helping Russian scholarship, and chaired a conference in St. Petersburg on "New Approaches to the History of Science and Technology." He was elected Foreign Member of the Academy of Natural Sciences, Moscow, Russia.

Professor Hammonds co-organized with Assistant Professor Robin Kilson of the History Faculty a national conference at MIT, January 13-15, on "Black Women in the Academy: Defending Our Name, 1894-1994." Over 2,000 women from across the United States, South Africa and the Netherlands attended. She published a review of Barbara Bates, Bargaining for Life: A Social History of Tuberculosis, 1876-1938 and an essay on Nurse Eunice Rivers Laurie and the Tuskegee Syphilis Experiment in The Black Women's Health Book edited by Evelyn C. White. She was awarded two fellowships for 1994-95: an Old Dominion Fellowship and a fellowship at the Institute for Advanced Study, Princeton. She was elected as a member of the School of Social Science for 1994-95.

Professor Kay was on academic leave during 1993-94. She published a book review of Robert Bud's The Uses of Life: A History of Biotechnology for Technology and Culture, and has four articles forthcoming later this year. In December, she gave the closing lecture, "Writing the Book of Life: Information and the Emergence of a Molecular Medicine," at the Anglo-Dutch Symposium on the History of Medicine in Nejmegen, the Netherlands. She organized and hosted the 30th annual Joint Atlantic Seminar for the History of Biology for 50 graduate students and their advisors from 17 colleges and universities which was held at MIT April 1-2. She served on the Mellon project committee and planned the Mellon Workshop, "Institutional and Disciplinary Contexts of the Life Sciences (mid- to late-20th Century)" which was held at MIT April 30. She was awarded a National Institutes of Health Grant on the Ethical, Legal and Social Implications of Human Genome Research for "Information and the Transformation of Molecular Biology," and was elected to the History of Science Society Council (two-year term), Committee on Honors and Awards.
Professor Keller was Director of MIT's Women's Studies Program and Director of the Mellon project on the History and Social Study of the Life Sciences. She co-organized with Professor Buchwald an international conference on "Entropy" which was held at the Dibner Institute, April 1994. She published "The Origin, History, and Politics of 'Gender and Science,'" "Language and Science: Genetics, Embryology, and the Discourse of Gene Action," "Rethinking the Meaning of Genetic Determinism," and Molecules, Messages, and Memory (working title), Columbia University Press, forthcoming. She attended five conferences and presented four papers. She also gave five invited lectures.

Professor Keniston continued as Director of Graduate Studies, Chair of the Doctoral Program Steering Committee, Chair of the Mellon Steering Committee. He has become a member of the Advisory Committee of the Cohen Institute of the History and Philosophy of Science at Tel Aviv University. He was a member of the Committee on Selection of the John Simon Guggenheim Memorial Foundation in New York City in February and member of the Reaccreditation Team evaluating Princeton University for the Middle States Association of Colleges and Schools on March 28-31. As a result of the nine Science-Government Workshops held at MIT during 1992-93, Professor Keniston, the project leader, spent the past year preparing a manuscript, The Fragile Contract. University Science and the Federal Government, edited by David H. Guston and Kenneth Keniston is to be published by MIT Press and is expected to be released summer 1994.

Professor Emeritus Marx was awarded the Hubbell Medal by the Modern Language Association for lifetime contribution to the study of American literature. The award was presented at the MLA annual meeting in Toronto in December. Mr. McElheny was on leave this past year working on a biography of Edwin Land. He remained active in fund-raising efforts for the Knight Fellowship Program. Professor Theodore Postol co-authored two articles: "Video Evidence on the Effectiveness of Patriot During the 1991 Gulf War" and "Highly Capable Theater Missile Defenses and the ABM Treaty." He organized the Technology, Defense and Arms Control Seminar Series for the Defense and Arms Control Studies (DACS) program. Professor Smith continued as Director of the STS Program and served on several Program and Institute Committees. He was selected as the first holder of the Leverett Howell Cuten '07 and William King Cuten '39 Professorship. He published an edited volume (with Leo Marx): Does Technology Drive History. The dilemma of Technological Determinism, MIT Press, 1994 and "Who Initiated the Computer Age?" in Reviews in American History 21, December 1993, pp. 687-96. He attended several conferences and presented papers or was a panel commentator at three of them. He also gave four invited lectures.

Professor Sherry Turkle was on leave this academic year. Professor Weiner published two articles: "Anticipating the Consequences of Genetic Engineering: Past, Present and Future: in Carl Cranor, ed. The Social Implications of the New Genetics and "Oral History of Science." He was Co-director of the Oral History Project on MIT Women Graduates, a Faculty Fellow at Ashdown House, and served on several Institute steering committees. He chaired a session at the History of Science Society annual meeting in Santa Fe, New Mexico in November, gave two invited lectures and served on several advisory boards.

MERRITT ROE SMITH
Overview
The Center for International Studies continues to meet the challenge of finding new and innovative ways to comprehend fundamental shifts in the global order. Whether those shifts are in the sub-fields of development, political economy, or security, CIS seminars, fellowship programs and research projects all reflect the search for new analytic approaches.

Defense and Arms Control Study Program
The MIT Defense and Arms Control Studies Program (DACS) analyzes the security alternatives available to the United States and other major and regional powers. Of great interest to the program is the role that emerging economic and environmental problems are likely to have in affecting international security arrangements, military options, and the resources made available for armed forces.

The Defense and Arms Control Studies Program sponsors a number of working groups—research collaborations of faculty, staff and students—with each group adopting a distinctive format and topic. One, led by Professor Harvey Sapolsky, examines American defense policies and has been especially concerned with the effect casualties have on the conduct and political acceptability of war.

Another, directed by Professor Stephen Meyer, has focused on the security policies of the former Soviet Union and most recently on the adjustments made by the defense industries of the former Soviet Union to new political and economic realities. A third, led by Professor Barry Posen, has concentrated on conventional warfare issues with special emphasis on armored forces. A fourth, led by Professor Sapolsky with participation from the MIT Aeronautics and Astronautics Department, has been concerned with the post-Cold War future of the world’s aerospace industry. A fifth, directed by Professor Theodore Postol, explores defense technology issues, most recently the effectiveness of the Patriot missile system in the Gulf War. A sixth, also led by Professor Sapolsky, has been examining the environmental legacies of the Cold War. And a seventh, jointly directed by Professors George Rathjens and Jack Ruina, has been exploring American national strategy and force requirements in a world without a Soviet Union. In addition, the program sponsors several seminar series including the DACS seminars, the Technology and Arms Control seminars, and the Defense Science seminars.

The director of the program is Professor Sapolsky, who has sought to encourage the initiatives mentioned above and to increase the program’s research and public activities. Among the publications are Breakthroughs, a new program journal now in its fourth year; DACS Facts, the program’s newsletter; and Soviet Defense Notes, the product of the Soviet Security Studies Working Group led by Professor Meyer. A working paper series has also been restarted. A close affiliation has been created with Dr. Marvin Miller’s longstanding research project on nuclear proliferation and with a newer one that Professor Emeritus Carl Kaysen is building at the American Academy of Arts and Sciences on international security norms. Several major conferences were held this year including one on Russian R&D activities, another on nuclear weapons in the Middle East, and a third on non-lethal warfare technologies. Major sponsors have been the Carnegie, Ford, and MacArthur Foundations. About 35 graduate students and six post-doctoral visitors are affiliated with the program this year, as is its first Navy Federal Executive Fellow, Commander Greg Hoffman.

Program in Development Studies
In keeping with the above-mentioned challenge to seek new approaches to a re-defined global order, the seminars within the Program in Development Studies continue to probe questions of ethnicity and nationalism, refugee movements, environmental policies and governmental and trade reform. The following seminars and workshops reflect those concerns.

The Seminar on Peoples and States: Ethnic Identity and Struggle, chaired in 1993-94 by Professor James Howe (Anthropology/Archaeology), examines issues of the creation of ethnic and nationalist identities in relation to the state; the Ford Development Seminar, a new workshop funded by the Ford Foundation, explores new conceptual approaches to the study of developing areas. Each lecture is followed by a workshop for doctoral students to discuss methodological issues in field research. It is organized by Dr. Elizabeth Leeds, (CIS).

The MIT-Harvard Joint Seminar in Political Development (JOSPOD), co-organized by Professors Myron Weiner (Political Science) and Samuel Huntington (Harvard University), dealt in its 29th year with the theme of Failed States and their Reconstruction; the Bustani Middle East Seminar, organized by Professor Philip Khoury (History Faculty) has treated such concerns as the prospects for peace in the Middle East, religious fundamentalism, and ethnic identity; the Inter-University Seminar on International Migration, organized by Professor Myron Weiner, concentrates on the themes of security implications of refugee flows and consequences of migration for the labor force; the Faculty Seminar on Global Environment and Sustainable Development, organized by Professor Nazli Choucri (Political Science), brings together faculty throughout the Institute for discussions on such issues as international environmental regulations and financial and business responses to environmental challenges.

Activities in Political Economy
Although there is no formal program on comparative and international political economy within the center, research on political economy has been a major focus of CIS. Faculty and graduate students have examined traditional concerns such as trade and competitiveness as well as emerging policy areas including the environment and health care. Three political economy seminars continued in 1993-94: the International Institutions and Political Economy Seminar, organized jointly by CIS director Professor
Kenneth Oye and Professors Robert Keohane and Lisa Martin (Center for International Affairs, Harvard); the MIT/Harvard Joint Research Seminar on International Environmental Affairs: Institutions, Politics and Policies, coordinated by Professor Eugene Skolnikoff (Political Science) and William Clark Harvard); and Political Economy of Global Energy and Environment, run by CIS Visiting Research Associate Michael Lynch. Several new research initiatives have also been undertaken. Professor Stephen Meyer (DACS, Political Science) is finishing a book on the economic consequences of environmental regulations within the US; Professor Oye is continuing a project on the causes and consequences of the regionalization of trade, has begun a study on the Comparative Uses of Compensation with Professor James Snyder (Political Science) and doctoral student Brian Burgoon, and, with CIS research affiliate James Maxwell has completed a paper on Self Interest and Environmental Regulation. Professor Suzanne Berger and Adjunct Professor Ronald Dore (Political Science) completed a study on the effects of economic liberalization on convergence of domestic institutions; and Professor Harvey Sapolsky (DACS, Political Science), is continuing a study on the containment of health care costs in the US.

MIT Japan Program

In late 1993, the Air Force Office of Scientific Research (AFOSR) renewed its two-year grant to the MIT Japan Program, Designating it as one of the 10 U.S.-Japan Industry and Technology Management Training Programs in the nation. This renewal reflected the high level of the Program's achievements. With major funding from this award, the Program has, over the past year, seen both growth and consolidation of its activities. At the same time, in response to recent developments in the Pacific Rim, the Program has developed a broadened vision for the future, which, while maintaining Japan central to its focus, will also encompass the other nations of that fast-growing region.

Education has remained central to the Program's activities, with the placement of MIT students in science, engineering, and management at the core. During academic 1993-94, the Program placed 53 interns in Japanese organizations, after overseeing their training in Japanese language and culture. This number is expected to grow to 60 in academic 1994-95. In order to make the interns' Japan-related expertise available to the our corporate and government sponsors, this spring, the Program published and distributed a resume book containing the CV's of 92 interns expected to come onto the job market in the next 18 months. In other educational activities during the period under review:

- Last autumn, the Program was chosen by the Department of Commerce to be one of the two centers to provide instruction to the first group of manufacturing engineers to go to Japan under the U.S.-Japan Industry and Technology Management Training Program.
- A sponsor training retreat was held in November, with 55 participants. This retreat was designed to provide an intensive look at Japan--a nation that is fiercely competitive in the modern world and yet determined to conduct business in a traditional framework.
- The Program's intensive courses in technical Japanese for computer science and electrical engineering and for materials science and related engineering had a record number of applicants and participants.
- The Program's Japan Effectiveness Training (JET), a week-long multi-media immersion in the "core values" of Japanese culture, business, and technology, was offered again for the third year, with 22 participants.
- In order to disseminate its knowledge of Japan to U.S. corporate and government organizations, the Program offered 13 Japan Target Seminars, a series of tailored modules that can be combined for one- or two-day sessions. Of these 13 sessions, eight were to the Program's corporate sponsors and five were given to government organizations; three were transmitted by satellite to multiple locations.
- The Program's Video Series was created in an effort to create Japan awareness at all levels of leading U.S. organizations in a way that will accommodate both time and budget constraints; the video series currently contains 20 titles. To date, more than 250 videos have been sold. Customers include training groups, libraries, other JIMT centers, sponsor and non-sponsor corporations, the Department of Defense, and the Department of Commerce.

Research is the second of the Program's three core activities. During the period under review, the Program's research activities included:

- The publication of 10 working papers, including three based on the above-mentioned Defense Technology Collaboration Survey.

Public Awareness is the Program's third core activity. During the period under review, the Program's public awareness activities have included:

- The publication of the first issue of the MIT Japan Program Science, Technology, and Management Report. This report, to be published bi-monthly, will provide up-to-date analysis of Japan's management of technology and its relationship to economic competitiveness. The development and implementation of three databases: 1) The Japan-Aware Professionals Database; 2) The Japan Science and Technology Experts Database; and 3) The Japan Trip Report Database.
- A meeting entitled "Organizational Learning in the U.S. and Japan: Tapping the Power of Adaptive Change."
- Continuation of the Program's dinner series, technology forum lectures, seminars, and informal talks.

Finally, during the period under review, the Program shifted its priorities to create a broadened new vision of the future. The fundamental aim of the MIT Japan Program has always been to stay "ahead of the future." When the Program was founded in 1981, it
anticipated the need to prepare U.S. scientists, engineers, and managers for the challenges posed by Japan's emergence as a major economic power. Now, the Program recognizes the new challenges reflected in the rapid rates of growth being achieved by many other Asian nations. To meet these challenges, the Program, while maintaining Japan as a major focus, plans to expand its networks and associations to other countries throughout the Pacific Rim region by developing new intern routes and sites and widening the scope of its research activities.

The Program now has 16 corporate sponsors—large American multinational companies—and continues to enjoy the generosity of a growing list of Japanese host companies, the APOSIR, the late Yaichi Ayukawa and his family, the Japan-U.S. Friendship Commission, and the Starr Foundation.

Seminar XXI: Foreign Politics, International Relations and the National Interest

Seminar XXI is an educational program held in Washington, DC for senior military officers, government officials and industry executives in the national security policy community. Conducted under the auspices of CIS, Seminar XXI recently completed its eighth year and continues to enjoy great success. Three MIT professors, Kenneth Oye, Barry Posen, and Myron Weiner (Political Science) served as co-directors, while founder Suzanne Berger remained active as a member of the Executive Committee.

The main objective of Seminar XXI is to develop among the program fellows new analytic skills for understanding foreign societies, including the instincts to ask different questions about the facts they receive on the job and in turn, to search out alternative interpretations of that data. Seminar XXI met nine times over the course of the year, with each session focusing on a different foreign country or policy issue. The approach is not meant to cultivate country or functional expertise, but rather, to provide concrete examples of the program’s essential point: that different frames of interpretation through which societies are understood yield fundamentally different answers to the questions these policy makers must ask and resolve. By considering the politics of each country through different frameworks of analysis, the range of possible explanations for the behavior of a set of countries important to the US is widened, as is the range of US policy options which can be considered systematically. Each of the nine sessions brought together distinguished faculty from US and foreign institutions.

Kalker Workshops on American Diplomacy and World Politics

As an offshoot of the Seminar XXI Program, the Center runs a parallel program at the Foreign Service Institute in Washington in which Foreign Service officers of varying rank participate in a series of workshops dealing with salient issues in global affairs. This series, bringing together State Department officials and distinguished faculty from American and foreign institutions seeks to devise enduring American strategies appropriate to a contemporary global environment. Workshops are led by Professor emeritus Lincoln Bloomfield (Political Science). They are funded by a generous contribution of alumnus Harry Kalker.

Fellowships

CIS sponsored three fellowship competitions for graduate students and faculty. (1) In the third phase of a three-year grant from the US Department of Education’s Institute for International Education, the center has awarded five academic year and five summer grants under the Foreign Language and Area Studies (FLAS) Fellowship Program. Languages being studied are Japanese, Swahili, German, Ukrainian, and Polish, and Arabic. (2) The International Energy Policy Research Grant competition is open annually to faculty, researchers, and advanced doctoral students working on any aspect of international energy, environment and related technology policy. In 1993-94 eight awards were given to students and faculty from the Departments of Political Science and Urban Studies and Planning. (3) In a new Federal initiative, the National Security Education Program provides study abroad scholarships for undergraduates and fellowships for graduate students. The Program, administered through CIS, awarded one undergraduate scholarship to an MIT senior.

Other Activities

During 1993-94 CIS was host to visiting scholars from Germany, Russia, Israel, Italy, Spain and Japan. In addition to the publications of the DACS and Japan Programs, the Center publishes a bi-annual newsletter, PreCIS, and two working paper series. CIS Working Papers and Findings, a series of article-length summaries of recently completed social science dissertations in comparative and international studies. The latter is funded by a grant from MIT alumnus Robert Wilhelm (’62).

ELIZABETH LEEDS
Integrated Studies Program

INTRODUCTION
The Integrated Studies Program (ISP) is one of MIT’s three programs designed for first-year students. ISP continues to strive for an environment that is intellectually alive, moves students to make new connections among disciplines, and sharpens their ability to challenge the ideas of others and to defend their own points of view. Students spent the past year examining technologies in the context of the societies in which these technologies developed, and they augmented their coursework with hands-on application.

In the 1993-94 academic year, the Integrated Studies Program (ISP) enrolled 33 students in fall (15 women, 18 men and 2 members of underrepresented minority groups) and 29 in spring (10 women, 19 men 3 members of underrepresented minority groups).

As part of the ongoing effort to attract a diversified student population, two ISP-style classes were held in July, 1993, for students attending the Interface program. In spring, ISP hosted an open house for women and minority students visiting MIT during Campus Preview Weekend.

ACADEMIC PROGRAM
Dr. Betsey Price, Senior Lecturer in the School of Humanities and Social Science, joined ISP’s faculty in fall. Dr. Price, an historian with particular interest in medieval technologies, taught in ISP’s two humanities courses, Technologies and Cultures (fall), and Technologies in Historical Perspective (spring). Other faculty team teaching the humanities courses included Arthur Steinberg (on sabbatical leave spring semester), Professor of Anthropology and Archaeology and ISP Director, Peter Dourmashkin, Lecturer, who also taught ISP’s physics recitations, and Chris Craig, Lecturer. Students studied six technologies or technological systems: food production, time keeping, weaving, blacksmithing, engine design, and telecommunications. The humanities courses were accompanied by hands-on workshops in which students practiced each of the technologies studies. Workshops were developed and taught by Mr. Craig.

Most ISP students enrolled in 8.01x and 8.02x, the first year physics options that require students to do weekly take-home experiments as part of the instructional method. Dr. Dourmashkin provided linkage between physics and humanities as a teacher in both components.

Faculty in spring implemented a new model for integrating writing instruction with the program’s humanities curriculum.

ISP offered a series of newly-developed freshman advisor seminars in fall. Topics included How Things work (Mr. Craig), Writing (Debra Aczel, ISP Program Administrator), Photovoltaics (Larry Bucciarelli, Associate Professor, School of Engineering). An additional advisor seminar, co-taught by Leon Trilling, Professor of Aeronautics and Astronautics and former director of ISP) and Alan Dyson, TIDE Senior Education Specialist, focused on How Toys Work. Former ISP students worked with entering freshmen as associate advisors. As part of its effort to reach a wider MIT audience, ISP opened two of the seminars to the general freshman population.

ISP ran a successful lunch speakers program fall and spring semesters. Speakers included a local eye surgeon, a Polaroid executive, and Charles Vest, MIT President.

INDEPENDENT ACTIVITIES PERIOD (IAP) ACTIVITIES
ISP and MIT’s Solar Car club jointly sponsored a hands-on introduction to the Solar Car during IAP. Under Dr. Dourmashkin’s direction, ISP and the Experimental Study Group (ESG) co-sponsored an IAP activity on robotics that was developed into a 6-credit seminar in spring semester.

In keeping with ISP’s emphasis on learning by doing, Marshall Hughes, Senior Staff Assistant, produced Mozart's The Magic Flute for an audience of children enrolled in MIT’s childcare center. MIT students and staff designed and built sets and created puppets. ISP alumna, Teresa Lau, created a coloring book as a companion text for the production.

OUTREACH
As part of the effort to bring the ISP model to a wider audience, Professor Steinberg, Mr. Craig, and Ms. Aczel served on the design team for How a City Works, a project that develops new approaches to staff development for public school teachers, based on the instructional model of ISP. Several former ISP students participated in
Undergraduate Research Opportunity Program (UROP) projects affiliated with How a City Works. ISP faculty and staff provided assistance to school districts in Boston, Cambridge, and other communities on ways of incorporating hands-on, ISP-style learning in their curricula.

ARTHUR STEINBERG
CURRICULUM

The Program in Women’s Studies offered nineteen subjects during the academic year 1993-94, with approximately 320 students enrolled. It also participated in sponsoring four graduate level courses through the new Boston-area Graduate Consortium in Women’s Studies at Radcliffe College, in which three MIT students enrolled.

Three new subjects were offered this year: SP402 The Development of Feminist Thought in Europe and America, taught by Visiting Professor Jill Ker Conway (STS), SP439 Edith Wharton and Willa Cather: Women Novelists and Their Analysis of Women’s Dilemmas, taught by Professor Cynthia Wolff (Writing and Humanistic Studies), and SP490J Women and Health in America, taught by Assistant Professor Evelynn Hammonds (STS). The Program is pleased to be expanding our offerings outside of the humanities with Women and Health in America. Additionally, this year saw the revival of an upper level seminar course for our majors and minors, The Development of Feminist Thought in Europe and America. The absence of an advanced seminar has been conspicuous, and women’s studies students have frequently requested a subject of this kind over the past few years. Hence, both courses have served to fill serious gaps in our curriculum.

We have adopted one new course for the next academic year, SP440 Myths of Gender: Masculinity, which will be taught by Associate Professor Henry Jenkins (Literature). We are currently working with the History Faculty to revive SP420J American Women’s History. At the same time, we have lost two thematically important subjects this year, both of which addressed the needs of important student constituencies at MIT, and proved to be very popular: SP472J Ecological Approaches to Environmental Problem-Solving and SP421J The World of Suzy Wong and M. Butterfly: Race and Gender in Asian America. We hope both of these subjects will be revived in the near future.

The Women’s Studies Research Room (WSRR), part of the Humanities Library and funded in part by the Women’s Studies Program, continues to be a valuable resource to Women’s Studies students and faculty alike. However, this resources in the WSRR have become almost inaccessible over the past few years because there are simply too many books for the available shelving. We are currently working closely with the library staff to renovate the room and provide more shelving in order to prevent the library from dismantling the collection. Acquisition of a computer terminal for the room continues to be a major goal for Women’s Studies.

STUDENTS

The Women’s Studies Program is proud to have graduated two majors this year, one a full major and one a joint major. We also have another major who will complete her degree this summer. Three minors graduated this year, and there are five underclassers who have already declared their intention to complete Women’s
Women's Studies minors. Nineteen 1994 graduates concentrated in Women's Studies, up from thirteen last year. There are currently twenty underclassers who have declared Women's Studies concentrations.

The Women's Oral History Project has involved a number of new students with the Women's Studies Program. These students work with Associate Professor Margery Resnick (Foreign Languages and Literatures) collecting oral history interviews of MIT's women graduates. Students working on this project have been thrilled to meet women who studied at MIT 30 or 40 years ago, and seem to approach their experience at MIT with more determination. Working on the oral history project provides these undergraduate interviewers with an academic framework within which to evaluate their experiences as both observers of and participants in MIT's unique culture.

PROGRAMS AND SPECIAL EVENTS

Programming special events continues to be vital to both the health and growth of the women's studies community at MIT. Because we have little control over our curriculum, but operate at the mercy of departments in more traditional disciplines, programming is the arena through which we are most able to reach new students and faculty, build ties to other programs and departments, and bring recent scholarship on gender to the attention of the MIT community.

Our major event this year -- coordinated in conjunction with the tenth anniversary of Women's Studies at MIT -- was the national conference, Black Women in the Academy: Defending Our Name, 1884-1994. The conference was organized by Professors Robin Kilson (History) and Evelynn Hammonds (STS), in close cooperation with Women's Studies, and with the assistance of staff in History and STS. This historic event brought together over 2,000 black women academics from around the country, and as far away as the Netherlands and South Africa. The three-day conference offered over 60 panels and roundtables, and keynote speeches by Professor of Law Lani Guinier; Johnetta Cole, the President of Spelman College; and long-time activist, Professor Angela Davis. Attendees at each of these keynotes exceeded the capacity of Kresge Auditorium, drawing conference participants, MIT students, and media personnel. Plans are underway for Spelman College to host a follow-up conference in June 1997. The Women's Studies Program has produced videotapes and a mailing list from the conference, both of which are already in high demand. Additionally, we are working on the creation of a national database of black women academics which will be available to researchers and educational recruiters once it is completed. There are also two books in the works which will document the conference. Over 700 conference t-shirts and 400 conference posters were sold, spreading the name of Women's Studies at MIT throughout the community of black women scholars around the country.

The other major effort in this year's programming specifically targeted students and faculty in the schools of science and engineering. We organized three events designed to appeal to members of the MIT community who might not normally identify as part of our constituency: a roundtable discussion on Women in Math, a
symposium on Women in Cyberspace, and an IAP panel discussion on women in science. All three events drew large and enthusiastic audiences. We scheduled the Women in Math roundtable to coincide with a conference celebrating women in math sponsored by the Department of Mathematics. While the conference brought many women mathematicians to campus to speak about their research, it did not include a forum for participants to discuss their position as women in the field. Our roundtable was designed as a complementary event specifically to provide such a forum. The students and faculty who attended clearly appreciated this networking opportunity, as they remained many hours after the presentation to exchange resources and information.

The Program in Women's Studies again coordinated the annual speaker series, Women and Politics, co-sponsored by the Department of Political Science and the Center for International Studies. The focus of the series this year was population and economic development, and offered talks by Saskia Sassen (Columbia University), Monica das Gupta (Harvard University), Susan Cotts Watkins (University of Pennsylvania), Natalia Rimashevskaya (Institute of Population Studies, Russia), Bina Agarwal (Institute of Economic Growth, Delhi) and Gillian Hart (University of California, Berkeley).

RESEARCH, PUBLICATIONS, AND SERVICE

Our publication, Women's Studies Around Boston, is sent quarterly to our mailing list of over 2,500 individuals. Every mailing of the newsletter elicits a rash of calls and letters from people requesting to be added to our mailing list. This publication provides vital links between the Program at MIT and women's studies scholars at other institutions and in the community.

Women's Studies is excited to have two visiting scholars from the University of Bremen in Germany coming to MIT next year to research theories of gender in the natural sciences. We hope the presence of these scholars will be inspirational to our students, and will enhance their ability to consider new approaches to exploring science and questions of gender in tandem.

The Women's Studies Faculty continued their active contributions to their individual fields. Most of these accomplishments are listed in the reports of their home departments, so special attention is given here to achievements relating to work on gender. Within the field of Women's Studies, Professor Ruth Perry (Literature) continues to serve as Chair of the Board of Directors of the Graduate Consortium in Women's Studies at Radcliffe, where she co-taught Narratives of Gender and Kinship in Periods of Emergent Capitalism this past spring. Professor Perry delivered lectures on feminist topics at the annual MLA conference in Toronto, and at conferences in Michigan and at MIT, as well as chairing sessions at the MLA and the tri-annual Berkshire Conference on the History of Women. She also published a chapter in a new book on gender and eighteenth century literature, and an article in the journal Women's Writing in the Early Modern Period, in addition
to several book reviews, and she has another article forthcoming *Modern Language Quarterly*.

Professor Evelynn Hammonds (STS) was awarded a fellowship by the Institute for Advanced Study at Princeton for the 1994-95 year, and won a Distinguished Scholar Award from UMass/Boston, as well as receiving an appointment as Co-chair of the Committee on Women of the History of Science Society, 1993-96. She served as Coordinator of the Audre Lorde Seminar on Multi-Cultural Education at the Wellesley Center for Research on Women, and as a member of the Board of Directors of the Fenway Community Health Center in Boston. She published an article in *The Black Women's Health Book* (2nd ed.), and book reviews in the *Women's Review of Books, Technology Review,* and the *Journal of American History,* as well as contributing several entries to *Black Women in America: An Historical Encyclopedia.* Professor Hammonds delivered talks on race, gender, and the history of science at the University of Minnesota, at the History of Science Annual Meeting in Santa Fe, NM, at the American Association for the History of Medicine Annual Meeting in Louisville, KY, and at a conference at The Claremont Graduate Humanities Center, and she delivered a keynote address on African-Americans in Science and Technology at Spelman College.

Professor Robin Kilson, who was on leave with a fellowship at the Bunting Institute all year, has been appointed Associate Member of St. Antony's College at Oxford University in the UK, where she will be in residence from April to June, 1995. She has agreed to edit two separate publications resulting from the Black Women in the Academy Conference: one three-volume set of the complete conference presentations (which will be published by Carlson in 1995), and one set of selected conference papers (to be published by the University of Massachusetts Press in 1995). Over the past year, she delivered lectures at Harvard, U. Mass/ Amherst, Radcliffe College, Haverford College, the American Academy of Arts and Sciences, Temple University, and MIT, and at the American Studies Association Conference in Boston in November.

Professor Evelyn Fox Keller (STS) presented papers to the National Research Council's Committee on Women in Science and Engineering, and at the History of Science Society Conference, delivered lectures at Swarthmore, Montana State University, Moorhead State University, Tufts Medical School, and presented a paper on biological regulation in Cuernavaca, Mexico. This summer, she will be delivering papers in Lisbon, Portugal and Berlin, Germany, as well as lecturing at several German universities. She has been appointed Visiting Professor at Bremen University for July, 1994. Professor David Halperin (Literature, on leave) continues his Visiting Fellowship at the Humanities Research Centre at the Australian National University. He was also awarded a postdoctoral fellowship by the Society for the Humanities at Cornell University, and the Michael Lynch Service Award from the Gay and Lesbian Caucus of the Modern Language Association. Professor Halperin published five articles, has a book on Michel Foucault forthcoming, and also managed to make 45 scholarly presentations during 1993-94.
Professor Elizabeth Wood's (History) article, "Dilemmas of Organizing Women Workers in Post-Revolutionary Russia, 1917-1930," will be included in a forthcoming volume on gender and class in modern Europe. Professor Henry Jenkins (Literature) has chapters on gender and popular culture forthcoming in the anthologies Strange Bedfellows, and Gender, Race and Sports. He was also awarded the next Class of 1942 Career Development Professorship. Professor Isabelle de Courtivron (Foreign Languages) was appointed the next Class of 1960 Fellow. Professor Margery Resnick (Foreign Languages) remains active in the Executive Committee of the International Institute in Spain, where she annually helps coordinate their international conference on Spanish women. She published a chapter on Carme Riera in the new anthology, Spanish Women Writers, last year. Professor Jean Jackson (Anthropology) continued her fieldwork on indigenous rights in Columbia during her sabbatical this year.

Beginning with the summer of 1994, Barbara Schulman will resume the position of Coordinator of Women's Studies, a post she held from 1987-1990. In the interim period, she has received her Masters Degree in Women's Studies from Clark University. Evelyn Fox Keller will continue to act as Director of the Program during Academic Year 1994-95.

EVELYN FOX KELLER
As reported in last year's overview, the Sloan School of Management has initiated a new curriculum for the two-year Master's Program. It has been a very successful introduction, with core courses offered during the first semester, followed by the opportunity for students to concentrate in tracks allowing for in-depth preparation, for distinctive career lines, such as financial management, financial engineering, new products, strategy, and information technology.

Ground was broken for construction of a new educational center for the Sloan School, named for the Tang family. This facility will augment our classroom capacity and provide substantially more space for student activities and team meetings.

A major emphasis during the year revolved around re-engineering and re-structuring of the School. A new organization that pulls together cross-cutting functions in a matrix to serve various program areas was introduced. A very intensive planning process was launched with several off-site meetings and the creation of special working groups to implement changes across the School.

On the research front, the various centers continue in full measure and a new over-arching theme has been introduced: "Designing the 21st Century Corporation."

During the year, the Sloan School received from the Lemelson Foundation a sizable gift to fund a prize in invention and innovation as well as funds for a chair and associated activities.

Many faculty of the School were involved in providing leadership for the Industry Summit held with the World Economic Forum in September, with Sloan School especially involved in automobiles, energy, health, and financial services.

TEACHING PROGRAMS

Undergraduate Program
During the 1993-94 school year, 41 seniors majoring in management science were graduated. Of those 41 seniors, 9 chose an option in information technologies, 23 selected finance, four concentrated in operations research, three in marketing research, and two in behavioral science.

Three of our graduates also received bachelor's degrees from other departments: one from the Department of Electrical Engineering and Computer Science, and one each from the Departments of Economics and Mathematics. A fourth student also received bachelor's degrees in economics and mathematics and a fifth student received simultaneously the SB degrees in Management Science and Computer Science and Engineering and the Master of Engineering degree.

At a post commencement reception, the Department recognized Sunredi Admadaja, a May '94 graduate majoring in management science, by presenting him the Sloan School of Management Senior prize. Awarded to outstanding senior management students, this prize, given annually, honors students who have achieved high scholastic standing and have demonstrated leadership and professional promise. Also honored during the year was Sloan junior Philip Tracadas who was named a Burchard Scholar. This award is given to students who demonstrate unusual abilities and academic excellence in the humanities, arts and social sciences.

This spring 91 students were enrolled in the Management Science Program. (Enrollment figure is based on the Registrar's fifth week count.) Nineteen additional students were enrolled in management science as their second SB department.

Sixty-two of our continuing undergraduates have declared their options as follows:
A large number of students from other MIT degree programs continue to enroll in our undergraduate subjects. In the 1993-94 academic year, using the accounting formula of Sloan's Dean of Administration to measure FTEs, there were 632 such enrollments which represents the classroom equivalent of 70 full-time students in addition to the 91 undergraduates in our program.

Faculty serving as undergraduate advisors were Professors Thomas J. Allen, Dimitris J. Bertsimas, Steven D. Eppinger, Stephen C. Graves, John D. C. Little, Michael A. Rappa, and Maureen A. Scully, along with Dr. Jeffrey A. Meldman, Director of Undergraduate Programs, Mr. David R. Breakstone, and Ms. Hillary De Baun, Assistant Director of Undergraduate Programs. Professor John S. Carroll continued as departmental coordinator of MIT's Undergraduate Research Opportunities Program (UROP) and Mr. Breakstone as departmental writing coordinator for Phase Two of the Institute Writing Requirement. Dr. Meldman served as chair of the Undergraduate Advisors Committee and as IAP coordinator, and Ms. De Baun served as IAP administrative coordinator.

Faculty serving on the newly created Undergraduate and Out-of-Course Policy Committee included Professors Allen, Andrew Lo, Stuart Madnick, and John Sterman, together with Dean Jeffrey A. Barks, Dr. Meldman, and Ms. De Baun. Professor Carroll served ex officio and Professor John Little chaired the committee.

During January 1994 we offered a number of IAP activities: The Foreign Currency Exchange Bourse Game, given for the seventh year in conjunction with Citibank, was coordinated by Professor Jiang Wang, Mr. David A. Weber, and Dr. Meldman. Professor John Little presented his series on "What is Management Science?" and Dr. Meldman and Professor Dan Nyhart conducted sessions in Dr. Meldman's series "A Brief Introduction to Law." "System Dynamics: Principles and Organizational Application" was sponsored by Professor Sterman. Lecturer David Breakstone conducted a workshop on oral presentation; and Hillary De Baun gave workshops on how to write a résumé and cover letter and on effective interviewing.

In addition to participating in IAP, members of our faculty contributed to undergraduate education at the Institute in the following ways: Professor Rappa and Dr. Meldman advised freshmen and also conducted freshman advisor seminars for their advisees. Fifteen of our faculty served on Institute committees related to undergraduate educational policy or to our undergraduate program: Professor Birger Wernerfelt served a second year on the Committee on Curricula; Professor Stephan Schrader joined the Faculty Policy Committee; Professor Michael Scott Morton served on the Committee on the Library System; Professor Julio Rotemberg chaired the Harold E. Edgerton Faculty Award Selection Committee for 1993-94; Professor Andrew Lo was a member of the James R. Killian, Jr. Faculty Achievement Award for 1994-95; Professor Eppinger served a third year on the Committee on the Writing Requirement; and Professor Allen again chaired the Athletic Board; Professors Little and Sterman, Roy Welsch, and John Hauser served on the Committee on Operations Research, which was co-chaired by Professor T. L. Magnanti; Professor Lotte Bailyn became a member of the IAP Policy Committee; Dr. Meldman served on the Prelaw Advisory Council, chaired by Professor Nyhart, and on the Committee on the Use of Humans as Experimental Subjects. Thirty-six faculty supervised UROP projects for students from departments throughout the Institute.

**Master's Program**

1993/94 saw the successful implementation of the new master's curriculum. Capturing the needs of managers in the twenty-first century, the curriculum emphasizes group work, management perspectives resulting from the collaboration of disciplines, and applied projects. Students may now opt for the self-managed track, where they design a program of study in general management to fit their individual needs, or the established management tracks, which will provide preparation for a specific career. Faculty across disciplines joined forces to design the multi-functional management tracks, which include tracks in Finance (Financial Engineering and Financial Management); Product and Venture Development; Strategic Analysis,
Consulting and Management; and Strategic Information Technology. In addition, subjects throughout the new curriculum contain significantly high levels of research and applied project work, prompting MIT to approve our plan for an optional thesis requirement. Starting with the Class of 1995, students who choose to substitute additional coursework for the thesis will receive the Master of Business Administration (MBA) degree, while those completing a thesis will continue to be awarded the Master of Science in Management (SM).

The strong sense of community among Sloan students continues to grow. Entering master's students were grouped in 60-person cohorts for the fall term subjects--orientation groups of 10 each were banded together to form these cohorts, so that team-building begun early could naturally follow through during the semester. These cohorts became the basis for academic, social, and student-governance activities. Faculty mentors, matched up with orientation groups, met regularly for lunch or dinner with their students, combining advising with comradeship. Second-year students again planned and led Orientation, which was expanded into two weeks to incorporate additional leadership and team-building activities.

The new curriculum allows students far greater choice in selecting not only electives, but also spring core subjects (students choose four of six offered fundamentals courses). Special afternoon-long sessions--CoreFest, CourseFest, and TrackFest--were organized to provide faculty a forum for sharing information about their subjects or management tracks, enabling students to make extremely knowledgable registration choices.

Admissions efforts this year were focused on strengthening the diversity of the student body. Minority and women applicants gathered at special receptions, where alumni/ae panelists focused conversation on the possibilities and practicalities of management education. The Alumni/ae Interview Program, which had been in pilot form for two years, was expanded to world-wide coverage. A Student Interview Program was begun with great success. This program, in conjunction with the highly successful Sloan Ambassadors Program, ensures that applicants learn what Sloan is really like from those who know it best. In turn, the additional perspective gained about the applicant helps the Admissions staff make the best possible selections.

_U.S. News & World Report_ (March 21, 1994), in its survey of business programs, raised Sloan's rating from fifth to second. Cited in particular were student selectivity (second among the top 25 management schools based on GMAT scores, undergraduate GPAs, and the percentage of applicants accepted), graduation rate (successful completion of the program being another clear measure of applicant quality), and placement success. Clearly the program continues to attract the highest caliber students. Over seven applicants vie for each space in the program, and the entering class, including Leaders for Manufacturing students, totaled 226. The following table presents a profile of the graduate classes of 1994 and 1995:

<table>
<thead>
<tr>
<th>Profile of Graduating Master's Classes</th>
<th>1994</th>
<th>1995*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Candidates:</td>
<td>237</td>
<td>226</td>
</tr>
<tr>
<td>US Citizens</td>
<td>163</td>
<td>140</td>
</tr>
<tr>
<td>Foreign Citizens</td>
<td>74</td>
<td>86</td>
</tr>
<tr>
<td>Women</td>
<td>60</td>
<td>59</td>
</tr>
<tr>
<td>Members of Minority Groups</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Median GMAT score</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td>Undergraduate Grade-Point average (out of 5.0)</td>
<td>4.5</td>
<td>4.4</td>
</tr>
<tr>
<td>Undergraduate Majors:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Sciences and Humanities</td>
<td>28%</td>
<td>29%</td>
</tr>
<tr>
<td>Physical Sciences</td>
<td>11%</td>
<td>11%</td>
</tr>
<tr>
<td>Engineering</td>
<td>49%</td>
<td>48%</td>
</tr>
<tr>
<td>Pre-Professional</td>
<td>12%</td>
<td>12%</td>
</tr>
<tr>
<td>Average Years Full-Time Work Experience</td>
<td>4.5</td>
<td>4.4</td>
</tr>
<tr>
<td>Mean Age at Admission</td>
<td>27</td>
<td>27</td>
</tr>
</tbody>
</table>

*Projected
The Ph.D. Program
During 1993-94, the Sloan School's Doctoral Program continued to hold a prominent position in the face of ongoing and intense competition from the other leading business schools. From our 463 applications, we made 30 admission offers and had 22 (73%) acceptances, distributed among 3 areas:

- Finance and Accounting 6 (1 US male, 1 US female, 3 foreign males, 1 foreign female)
- Management Science 5 (2 US males, 3 foreign males)
- Behavioral Policy Sciences 11 (1 US female, 7 foreign males, 1 foreign female, 2 US males-1 under-represented minority)

The overall percentage of US applicants was 35% and the majority of foreign applications continue to come from India and Korea and several other countries within Asia. We continue to cooperate with the efforts of the American Assembly of Collegiate Schools of Business (AACSB) to recruit more qualified under-represented minority applicants, and work on our own strategies for identifying prospects and sources. The bulk of the program's graduates pursue academic careers.

The Doctoral Program Committee, headed by Professor Birger Wernerfelt and coordinated by Sharon Cayley, continues to grapple with the diverse problems of a very individualized program, including addressing time taken to complete the program (5 years) through early research ties to faculty, and financial aid awards that are competitive with our principal rivals.

CAREER DEVELOPMENT OFFICE
With the job market improving across the US in the last year, the Career Development Office took concrete steps to target specific areas of interest to students and significantly increase the number and mix of recruiting companies. As a result, the Sloan School enjoyed a 20% increase in the number of firms recruiting on campus, a 75% increase in student satisfaction with career services, and a number one ranking for placement among business schools by US News & World Report.

Several career development program initiatives contributed to these positive results. The CDO organized a Career Fair in California, managed a direct mail campaign aimed at entrepreneurial high tech firms, staged events showcasing successful alumni career paths, and increased individual career counseling.

Our preliminary placement data strongly suggests that Sloan will retain its leadership position in 1994. The range of base starting salaries was $30,000-$120,000, with a median of $68,000, up from $65,000 last year. The trend toward services professions continues. Thirty-five percent (35%) selected careers in consulting, 24% in finance, and 16% in operations/manufacturing, compared to 31%, 18%, and 18% respectively in 1993. The top hirers of Sloan graduates this year were McKinsey (9), A.T. Kearney (8), General Motors (5), Hewlett-Packard (5), and Intel (5). Students received an average of 3.1 offers each.

As the academic year draws to a close, 96% of our 1994 Masters' graduates have accepted permanent positions in 20 countries around the world. This outstanding record for employment will help Sloan continue to attract the brightest and most capable students.

ALUMNI/AE RELATIONS
The Office of Alumni Relations continued its programs to provide Sloan graduates with social, academic and professional benefits, allowing them to effectively connect with each other and the Sloan School through (1) alumni club programs (2) alumni career services (3) reunions (4) educational convocations (5) alumni/admissions and student programs and (6) an on-line MIT Sloan Alumni News Network.

Alumni Club Programs
During 1993-94, Sloan alumni participated in the global network of over 100 MIT and Sloan alumni clubs. The Sloan Club of Boston hosted career seminars, dinner with Dean Urban, back to the classroom with Mary Rowe and Andrew Lo, and speaker events with Henry Termear, Warren Rudman, and Terrance Murray. The club also hosted a gathering with admitted students, marketing and financial services
networking receptions and an economic forecast dinner. Among its most well-attended events were "Multimedia in the Office: Exploring the Heights" and the "Evolving Role of the Corporate Board".

The Sloan Club of Northern California sponsored a dinner with the Dean, reception with prospective candidates, a Career Forum, San Francisco symphony evening, Spring barbecue, gathering with admitted students and monthly consumption functions. It held Executive Speaker events with Steve Kirsch, James Abrahamson, and Lisa Conte and a program, "Highly Educated Women and Men at Work: Breaking the Glass Ceiling". The club also hosted MBA networking events with other Bay-area business school clubs.

The Sloan Club of Southern California sponsored a reception with the Dean, a back to the classroom with Andrew Lo and a Sloan Evening with prospective candidates. The Washington D.C. club held a reception with Deputy Dean Paul Healy while the club in Chicago held a speaker program with Deputy Dean Robert McKersie. The Sloan Club of New York hosted a reception with Dean Urban, a Sloan Evening, and an event entitled "Demystifying Derivatives". Alumni also participated in club programs in Colorado and Iowa. New Sloan Clubs were established in the European Community, the Netherlands, and Seattle. Internationally, alumni hosted events in Buenos Aires, London, Paris, Santiago and programs through Sloan Clubs in Japan and Spain. In Hong Kong, a reception was held for local alumni and current Sloan students. Gatherings with alumni and students were organized in Mexico and Taiwan. In addition, Sloan alumni participated and held leadership roles in many of the MIT clubs throughout the world.

Alumni Career Services/Career Development
Alumni Relations took several initiatives to provide career resources to enhance the professional development of graduates and to respond to their career management needs. The School developed a bibliography of job search publications, tips on networking, an executive search list, recruiter and job contact lists and enhanced access to the ProNet placement service. The School also engaged a career counselor to provide advice to alumni on job search strategy, career transition and resume development. We also expanded an alumni job newsletter, published twice a month with all current job listings the Sloan School receives. In addition, we hosted a career management seminar entitled, "Success Stories in Career Transitions" and a forum entitled "Career/Family Issues as a Catalyst for Corporate Change".

Sloan held its second annual California Career Forum for alumni and students, which consisted of an informational exchange among Sloan alumni, students and company representatives and interviews. Throughout the year, Sloan alumni also volunteered to assist students with their job search and participated in workshops to help students improve interview and resume writing skills. In addition, many alumni returned to recruit Sloan students to their companies and organizations.

Alumni/Admissions and Student Programs
The Sloan School implemented a nationwide Alumni Interview program, offering applicants the opportunity to interview with a Sloan alumnus. Over 150 alumni volunteered as interviewers and nearly 200 alumni volunteered internationally to serve as admission contacts in their local area. Alumni also participated as speakers at admissions receptions for minority and women applicants and at Open House. The School hosted Sloan Evening receptions with alumni and prospective candidates in Detroit, Los Angeles, New York, San Francisco, Washington D.C., Buenos Aires, London, Madrid, Paris, and Santiago.

The Mentor Program continued into its third year with nearly 250 alumni volunteers. First-year masters students were matched with alumni from Boston, New York, and Northern and Southern California based upon industry, job experience and career interests. In addition, the Alumni-Student Dinner Program, in which Boston-area alumni host dinners for master's students, provided students and alumni with the opportunity to have informal conversations about Sloan, career issues and work and family life. Many students also attended alumni club programs such as a marketing networking reception, financial services event and a reception with alumnae and the Sloan Women In Management (SWIM) club.

To encourage more interaction between alumni and students, the Alumni Office distributed alumni directories to current Sloan students from all programs. An alumni resources and services guide was published and distributed to graduating students to inform them of volunteer opportunities and
information about clubs, convocations, reunions, and career services. Graduating students were also provided a discount to NEXIS and the America Online/MIT Sloan Alumni News Network.

**Reunions**
Reunions were held during the weekend of June 2-5, 1994 for the Classes of 1989, 1984, 1979, 1974 and 1969. We enjoyed a record turnout with 245 graduates and guests in attendance, a 50% increase from the participation the previous year. The reunion program included a Boston Symphony concert, MIT Technology Day seminars, a Sloan "Consumption Function", a Boston Harbor boat cruise/luncheon, Class-specific parties, and a dinner/dance with remarks by the Dean. Reunion committee volunteers were recruited to encourage classmates to attend and to participate in the reunion class giving program.

**Educational Convocations**
Following 1993 Sloan convocations in Northern California entitled, "Doing Business in the Pacific Rim: The High-Tech Perspective" and in Belgium entitled, "Building a Learning Organization: How to Train Decision Makers to Deal with Complexity", a convocation for Senior Executive graduates was held in Cambridge in October 1993 and focused on the "21st Century Corporation".

**MIT Sloan Alumni News Network**
To promote continued communication between alumni and the Sloan School and to allow graduates to network with each other, the Office of Alumni Relations established the MIT Sloan Alumni News Network, an online service available through America Online. The service provides Sloan alumni with information about alumni activities and programs, news about the School and information about classmates and faculty. It also provides access to the Internet, an e-mail address, and other benefits as a member of America Online--business news, stock quotes, on-line daily newspapers, etc.

**MIT Sloan Memorabilia**
The Sloan School successfully negotiated an agreement with the Harvard/MIT Coop to market and sell memorabilia with the new Sloan logo to alumni, students and the general public. Products are available in the Coop's retail locations and through direct mail. In addition, we licensed the new Sloan logo and established five trademark classes to allow other vendors to market Sloan products.

**INTERNATIONAL COLLABORATION: MIT/NTU**
The Sloan School signed in 1991 a five-year contract with the Nanyang Technological University (NTU) to assist in the development of a comprehensive business school in Singapore. Under the agreement, MIT faculty visit NTU to offer research seminars, participate in the development of curricula, and meet with students and faculty. Additionally, NTU faculty participate in Sloan School programs as visiting scholars. A further objective of the collaboration is cooperative research projects. During the third year of the collaboration, all of these activities continued with considerable enthusiasm being expressed by NTU and Sloan Faculty.

**EXECUTIVE PROGRAMS**

**Alfred P. Sloan Fellows Program**
On May 27, 1994, 52 Alfred P. Sloan Fellows were awarded the degree of Master of Science in Management. The Class of 1994 represented a broad diversity of backgrounds and interests, and again was drawn from a wide range of organizations from the United States and abroad. The Sloan Fellows Program was the first executive education program in the United States and is now in its 63rd year. Just prior to their graduation, the Sloan Fellows completed a three-week International Management Field Trip to Latin America. They visited with leading government and industrial representatives in Argentina, Brazil, Chile, and Mexico. The demand for the Program continues to be strong, and the quality of the nominations is extremely high. On June 17, 1994, the Class of 1994-95 arrived; there are 54 participants in the 1994-95 program.

The Director of the Sloan Fellows Program is Susan Lowance. Professor Robert McKersie served as Chair of the Faculty Program Committee.
**Program for Senior Executives**
The Program is an international program. Non-US executives made up 65% of the class; and curricula are increasingly focused on current and future global management realities.

Both US and non-US managers are nominated, in part, to benefit from the rich, varied cultural backgrounds and experience of the participants.

Professor Gabriel Bitran completed his term as Chair of the Program Faculty Committee. Professor Eleanor Westney will assume that position in September.

Ms. Judith Mason continues as Program Coordinator, and Dr. Charles Grader as Director of the Program.

**Special Executive Programs**
Sloan School of Management faculty participated in four one-week Special Executive Short Courses this summer for mid and senior level executives: Management of Change in Complex Organizations, Corporate Strategy, System Dynamics: Modeling for Organizational Learning, and Negotiation: Theory and Practice. One hundred eighty-seven executives participated in the four programs and nearly every continent was represented.

In addition to the one week programs, we continue to offer custom designed programs for those corporations seeking education in areas of Sloan faculty expertise. For example, twenty-two representatives from the Redstone Arsenal in Alabama attended a three day program during the Spring of 1994. Eleven of the participants were MIT/Sloan alumni. The arsenal is also an ICMOT sponsor.

**MANAGEMENT OF TECHNOLOGY**
The MIT Management of Technology (MOT) Program was the first masters level program in the world to focus on the strategic management of technology and innovation. Established in 1981, under the auspices of the Sloan School and the MIT Engineering School, it is a key offering in the Sloan School's portfolio of executive education programs.

Designed to develop strategic leaders for private and public organizations worldwide, the Program offers a special managerial perspective for technology-based leaders. Participants are selected who have, on average, ten years of organizational experience. During the twelve-month Program, participants write a thesis and graduates earn the degree of Master of Science in the Management of Technology.

Because of the unstable international economy, an unexpectedly large number of accepted participants withdrew immediately prior to the beginning of the 1993-1994 academic year. This resulted in an unusually small class of 37 participants. During the year, marketing efforts were enhanced to insure the continuation of class growth toward the desired class of 50-55 participants.

The curriculum has remained stable, dividing the required studies into five areas linked to the technology-based organization: Strategy, Human and Organizational Factors, Managerial Decision Making, Managing Product/Process Development, and Applied Research (the thesis).

The Field Trip for this year was taken to London, England, and included meetings with organizations such as British Petroleum, Rolls Royce (engines), and Bass and Rover. The practice of offering joint MOT and Sloan Fellow electives has continued, with great success.

Rochelle Weichman continues as Director of the MOT Program, with Professors Edward B. Roberts of the Sloan School and Thomas H. Lee of the Department of Electrical Engineering and Computer Science, continuing as Co-Chairs of the Program.
RESEARCH

ECONOMICS, FINANCE AND ACCOUNTING (EF&A)
Faculty research in Economics, Finance, and Accounting applies the tools of economic theory, statistics, and operations research to a wide range of problems. Work is directed to issues of economic policy, to problems in pure theory, to empirical questions, and to the development of improved decision-making methods for practicing managers.

Applied Economics
Professor Ron Adiel's work has been in the area of earnings management in the insurance industry. His current work focuses on reinsurance as a tool for enhancing the financial reports of insurance firms. Other topics of interest include the valuation of insurance firms, and differences in reporting behavior of insurance companies across different countries.

Professor Ernst R. Berndt is carrying out additional research on the diffusion of technological innovations, on the measurement of price changes that incorporate quality variations, and on productivity measurement. Much of this work focuses on the pharmaceutical industry. Professor Berndt also serves as area head of the Applied Economics, Finance, and Accounting groups at the Sloan School.

Professor S. Lael Brainard is starting research on the effects of offshore production on domestic employment, after completing research on the relationship between multinationals and trade and on strategic trade policy. She teaches classes on international trade and competition and on international macroeconomics. She will be on leave as a White House Fellow for academic year 1994-95.

Professor Henry D. Jacoby has continued research on global climate change and the application of techniques of corporate finance to the evaluation of resource projects under highly variable output prices. He also serves as a co-director of the Joint Program on the Science and Policy of Global Change, a shared activity of the M.I.T. Center for Global Change Science and the M.I.T. Center for Energy and Environmental Policy Research.

Professor Don O. May has just completed a project that investigates how managerial motives influence incentives to make diversifying acquisitions. His current projects also relate to the potential conflicts between managers and owners. Most notably he is investigating how portfolio managers change their security holdings given past performance and the firm's compensation structure.

Professor Robert S. Pindyck continued his research on irreversible investment decisions, focusing on investments of uncertain cost, and capital replacement decisions. He also conducted research on environmental economics, studying the implications of irreversibility's for environmental policy design.

Professor Nancy L. Rose studies competitive interactions among firms and the determinants and effects of government regulatory policies. Her current research projects include an investigation of airline pricing behavior, analysis of executive compensation and corporate governance practices, and the effects of regulatory reform on generic competition in pharmaceuticals.

Professor Julio J. Rotemberg has continued to work on the analysis of the effects of imperfect competition on fluctuations in economic activity. In joint work with Michael Woodford he has shown that the extent of imperfect competition in the U.S. economy can rationalize the extent to which economic activity has tended to drop after the pre-1980 oil price increases. He has also continued to work on economic models which explain relationships among employees inside organizations.

Professor Richard Schmalensee continued to serve as Director of the Center for Energy and Environmental Policy Research. He has continued to study topics related to the economics of environmental policy and global climate change. He has also studied competition policy in Russia. He continued to serve on the Executive Committee of the American Economic Association.
Professor Thomas M. Stoker has continued his work on the development of semi-parametric estimation techniques and their application to economic problems. He has also done further work on the implications of aggregation for the analysis of consumer demand.

Professor Alwyn Young continued his research on economic growth and development in the newly industrialized economies of East Asia.

Finance

Professor John C. Cox continued his work on intertemporal consumption and portfolio policies. He developed efficient methods of computing optimal policies in a variety of new circumstances. He also extended his previous work on the term structure of interest rates.

Professor John Heaton is investigating the implications of models in which individual agents cannot completely diversify their idiosyncratic income. The implications of the models for savings, asset returns, and income distribution are being compared with actual data. Over the past year he taught a Ph.D. level course in monetary economics and a core course in finance theory for masters students.

Professor Chi-fu Huang is working on optimal consumption-portfolio policies for preferences that exhibit local substitution. He is also studying an inverse optimal portfolio problem and an empirical investigation of the auctions of Treasury bills.

Professor Andrew Lo has launched the Research Program in Computational Finance, a partnership between industry and academia designed to support and promote basic research in quantitative financial economics. As of June 1993, sponsors of the RPCF include: Bridge Information Systems, Carroll McEntee and McGinley, Commodities Corporation, Digital Equipment Corporation, and LBS Capital Management.

Institute Professor Franco Modigliani has devoted his research to two subjects. The first is the depression that is developing in Europe where unemployment is reaching the magnitude of the "Great Depression." He has concluded that it is almost entirely due to the restricted policies of the Bundesbank and to the fact that the other members of the EMS are boxed in by the EMS rules and have no way of pursuing an independent reflationary policy, except by abandoning the EMS. He has been particularly interested in the developments in the UK that opted out of the EMS and Italy that was forced out last September. Both countries have moved to floating exchanges, thereby freeing themselves from the restraints of the Bundesbank interest rate policies. His other main interest has been a study of saving behavior in China. This behavior is extraordinary, with the saving rates very low until the end of the 70's and becoming the highest in the world in the following decade. In research undertaken with the support of the People's Bank of China, it has been shown that this behavior can be accounted for primarily by the Life Cycle Hypothesis together with very marked movement in population trends and some intermittent large spurts of inflation.

Professor Stewart C. Myers continued to work on assessing organizational theories of corporate financing, in which the mature firm is viewed as a self-interested value-maximizing coalition and dividend policy is analyzed as an implicit contract with outside investors. He is working with Professor Lakshmi Shyam-Sunder on empirical tests of corporate financing policy and the evaluation of alternative approaches to estimating the cost of capital.

Professor David Scharfstein has been doing research on a wide variety of topics in theoretical and empirical corporate finance. His recent projects include analyses of Japanese corporate financing arrangements, the economics of financial distress, corporate risk management, and the links between product market competition and corporate financial structure.

Professor Jeremy C. Stein continues to work on a broad range of theoretical and empirical topics in corporate finance and asset pricing. His current research includes an analysis of the links between corporate financial structure and monetary policy.

Professor Jean-Luc Vila is currently studying the impact of various market imperfections, such as transaction costs or leverage constraints, on the behavior of economic agents in financial markets. He is also continuing his research in the area of economics of information.
Professor Jiang Wang has been working on equilibrium models of dynamic stock prices and trading volume under asymmetric information. He is also working on the problem of optimal contracting between investors and money managers.

**Accounting**
Professor Andrew W. Alford continued work with Mark Zmijewski and Jenifer Jones, both at the University of Chicago, on firms' filing behavior of annual financial statement data on Form 10-K with the Securities and Exchange Commission. He also began work with Mark, Jennifer, and Richard Leftwich, also of the University of Chicago, on the relative informativeness of accounting disclosures in different countries.

Professor Ravi Bhushan's work has been in the area of efficiency of capital markets. He has developed a model to examine the impact of "short-termism" on the behavior of asset prices. In another paper, he analyzes the puzzle of the delayed price reaction to earnings announcements.

Professor Paul M. Healy has worked on three research areas. The first examines how firms perform after mergers and acquisitions. The second examines problems faced by firms' managers in communicating information on their firms' performance to outside investors. The final research topic examines how trends toward globalization of financial and product markets have affected cross-country merger and acquisition activity.

Professor Alfredo Kofman is working on the design of new performance measurement, evaluation, and incentive systems. He is testing the implications of his conceptual models in the manufacturing companies associated with the Leaders for Manufacturing program. He is also studying the impact of management information systems on organizational learning and modeling the incentive mechanisms that may lead managers to behave in counterproductive or myopic ways. Professor Kofman has continued his research on collusion-proof mechanism design and optimal communication algorithms.

**MANAGEMENT SCIENCE**
The Management Science area encompasses the following concentrations: marketing, operations management, information technology, probability and statistics, and operations research. New initiatives, are being implemented by the members of the area.

Members of all the subgroups have continued to play a role in the Leaders for Manufacturing Program (LFM) in a wide variety of functions. In particular Steve Graves is a co-director of the program. A significant number of LFM students have been and are being advised by faculty of the Management Science area.

**Awards and Honors:** Professor John Hauser received the John D.C. Little Best Paper award for 1993, given by the TIMS College of Marketing. Professor Hauser also received a Sloan School teaching award. Professor Wanda Orlikowski was awarded the Gordon Y. Billard Career Development Chair in Information Technologies. Additionally, one of her articles won the best paper award for papers published in *MIS Quarterly* during 1993. Professor Lawrence Wein won the Erlang Award for the outstanding young probabilist under age 35. The Operations Research Society of America founded the award this past year.

**Operations Management**
Professor Gabriel R. Bitran has been working on the development of models to analyze manufacturing operations with variable yields. These are typical of semiconductor manufacturing and other high technology environments, such as fiber optics. He has continued his research in the service industry studying reservation systems. The context in which the study is being performed is the hotel industry. The objective is to develop models to allow managers to match supply and demand. Professor Bitran continues to work on a methodology for assessing the status of quality in services.

Professor Stephen C. Graves continues to focus on understanding the value of production flexibility in various forms, and on modeling variability in manufacturing systems and supply chains. He is supervising LFM projects at Kodak, United Technology, Boeing, and General Motors.
Professor Charles H. Fine is studying manufacturing equipment development and sourcing in the semiconductor and automobile industries. His work attempts to understand better how manufacturing firms manage supplier relations with equipment suppliers and how equipment suppliers manage their product development processes.

Professor Lawrence Wein continues to develop new methods and principles for the scheduling and control of production operations, as modeled by a network of queues. He is also developing cost effective testing procedures for protecting the blood supply from HIV contamination.

Professor Karl T. Ulrich has several projects in the area of product development. His current research partners include Boeing, United Technology, and General Motors.

Professor Steven Eppinger conducts research in the field of manufacturing, with a focus on product design and development. He specializes in the study of large product development projects and has worked with development teams at many firms in the automotive, electronics, and consumer products industries.

Professor Anantaram Balakrishnan continues to work on modeling and solving large-scale optimization problems in manufacturing, telecommunications, and network design. He has developed, analyzed, and tested algorithms to design hierarchical and survivable networks, optimize the assignment of products to parallel electronics assembly lines, and reduce cost through order combination in an aluminum sheet manufacturing operation. He has also addressed coordination issues for reactive problem-solving in manufacturing.

Professor John Sterman's research includes experimental studies of human performance in dynamic decision making environments. He designs and evaluates the effectiveness of "management flight simulators" for research and teaching, and studies the use of such tools among corporations. He also continues his research on the application of nonlinear dynamics in human systems ranging from individuals to the economy.

Operations Research and Statistics
Using statistical and probability methods. Professor Arnold Barnett has studied subjects that shape public policy, particularly in the areas of aviation safety and criminal justice. He has also done recent work on voting systems, war casualties, and the question "when is a model good enough?"

Professor Gordon Kaufman continues to focus on the exploration of primary energy resources and on statistical and mathematical problems in resource estimation. He is also studying how to assess large and complex system uncertainties when given an incomplete specification of the probability structure of such systems, as well as statistical analysis of software reliability.

In addition, Professor Roy Welsch has studied nonlinear process control, robust experimental design, the use of graphics in statistical analysis, computer guided diagnostics in statistics, and risk management in financial credit services.

Professor Bin Zhou focuses his research on financial time series analysis. He uses high frequency data from foreign exchange markets to estimate volatility and forecast trends of the market.

Professor Dimitris Bertsimas has worked on combinatorial optimization, probabilistic analysis of combinatorial problems, stochastic and dynamic optimization and applications of or in the airline industry.

Professor Robert Freund has studied new methods for solving linear programming problems, developed scheduling models for classroom scheduling, and studied methods for analyzing reliability of stochastic networks with realm matrices.

Professor Thomas Magnanti has studied optimization models and algorithms for problems in communication system design, production management and distribution systems planning.
Professor Jeremy Shapiro has continued to work on a variety of applications of mathematical programming in manufacturing, logistics planning, and financial planning.

Professor James Orlin has worked on developing faster algorithms for problems in network optimization. He is also working on problems in computational molecular biology, and is applying this work to the human genome project.

Professor Vien Nguyen has worked on topics in applied probability, diffusion processes, queuing theory, and performance analysis of queuing networks that arise in manufacturing and telecommunication applications.

**Information Technologies**
The increasingly widespread availability of information from numerous sources both within and external to organizations and the rapid changes in information technology poses significant opportunities and challenges to management. The Information Technologies Group addresses these issues by experimenting with new technologies such as expert systems and heterogeneous databases, by examining a variety of strategic information applications, and by studying underlying organizational issues.

Professor Erik Brynjolfsson focuses his research on the economic impacts of information technology, including organizational design and productivity. He has developed models of the relationship between information costs and the allocation of decision rights within and among firms. His econometric work assesses some of these models and also estimates the impact of information technology on various measures of economic performance. His recent findings show that information technology has contributed much more to productivity than indicated by earlier studies.

Professor Thomas Malone established the Center for Coordination Sciences which focuses on developing computer systems that help people work together in groups and organizations, predicting and suggesting changes in human organizational structures that accompany the use of information technology, and developing computer systems whose internal structure is based on insights gained from analyzing human organizations. A major new effort focuses on the development of a "Process Handbook" to help companies explore new ways to conduct business.

In related research, Professor Stuart Madnick has been analyzing Composite Information Systems (CIS) that facilitate applications requiring inter-organizational and intra-organizational information exchange. A specific focus has been "context interchange" which deals with differing meanings between the source and the receiver. A prototype system, called CIS/TK, which currently integrates multiple disparate information systems has been developed by this group. Extensions to deal with rapidly changing semantics and identification of sources in the emerging "information highway" are being developed.

Professor Chris Kemerer has developed models to aid the management of software development and is developing and testing measures of software productivity. His most recent work focuses on metrics and models for evaluating object-oriented technologies.

Professor Wanda Orlikowski's research concerns the relationship between information technology and organizational change. She has continued her research into the automation of systems development work, the role of electronic communication media and groupware in coordinating work, and the restructuring of organizations through information technology.

Professor Richard Wang has extended his work on the issue of "where is the data from?" in database management to address issues involved in developing Quality Data Base Management Systems (QDBMS). Professor Wang continues to provide leadership to the newly-formed Workshop on Information Technologies and Systems (WITS) which serves as the forum for the exchange of ideas by faculty and leading industry practitioners in the Information Systems field, and initiated the Total Data Quality Management (TDQM) Consortium with Professor Stuart Madnick.

Dr. Amar Gupta continued his research on automated reading of handwritten characters, especially on bank checks, and the MIT Technology Licensing Office has applied for patent rights on the architecture and
algorithms invented by him and his researchers. His work on integration of heterogeneous information systems envisages the design of a new national transportation information infrastructure. Jointly with Professor Stuart Madnick, he established the Productivity from Information Technology (PROFIT) initiative.

Professor Paul Resnick designs electronic brokerage services for the information superhighway. He has developed GroupLens, a system for sharing subjective evaluations of products, especially information products. He has also analyzed market-based mechanisms for compensating the evaluators.

Dr. John Rockart continues his work on critical success factors, systems development, and management of data resources. He is expanding his work on executive support systems downward into the organization as Management Support Systems and is exploring the use of information technology to manage interdependent organizations of a firm.

Dr. Jeffrey Meldman continues to track developments in the legal protection of information, particularly proprietary rights in software and personal rights of privacy.

Marketing
Professor John Little has focused much of his energy on "The Consumer Packaged Goods Project," an activity to understand the impact of large, single-source data sets. One focus of this project is in modeling advertising effects, that is, using laboratory experiments with extensive panels of households to understand how television exposures affect both brand choice and the size of packages bought by customers. Other foci are on how newspaper features affect store choice and how cents-off coupons affect profitability. John Little is also working on the development of some basic "laws of manufacturing."

Professor Glen Urban having assumed the position of Dean, has continued his research on new-product development. One major focus (with John Hauser) has been on the refinement of a multi-media system to accelerate information to consumers so that we can observe and predict decision processes that normally take place over a period of months. The newest application (with Bill Qualls) is to forecast the adoption of a new medical device (hematology). He has also continued his research on the advantage to being first to market. In addition, he has published Design and Marketing of New Products, (2nd edition) with John Hauser.

Professors John Hauser has continued his responsibilities as Editor-in-Chief of Marketing Science. His research over the past year has focused designing products in response to the voice of the customer and on managing business for long-term profit based on customer satisfaction. Together with Birger Wernerfelt they have developed practical, yet theory-based, methods to motivate employees to focus on customer satisfaction. This year they developed methods to provide incentives to upstream research employees based on the evaluations of intermediaries such as product-development teams. John Hauser is continuing this work with a focus on metrics to evaluate R&D.

Professor Birger Wernerfelt has continued his research on how pricing systems are developed. For example, he has explored why in the United States consumers bargain with automobile dealers but in some European countries the price is taken as posted. Similarly, in Japan, the dealer comes to the consumer but in the United States the consumer comes to the dealer. He has completed papers on salespeople and brochures, on employees and independent contractors, and on alternative ways to govern trading relationships.

Professor William Qualls' areas of specialization are group decision behavior and modeling marketing response behavior. He uses behavioral paradigms to aid in explaining and predicting marketing phenomena and managerial behavior. Most recently his research has focused on how firms can maximize their profitability through customer and employee satisfaction.

Professor France Leclerc has continued her research on how consumers make product decisions, and how consumers react to waiting and delays in services. More specifically, she investigates how sensitive these two processes are to exogenous factors such as time pressure and managerial interventions. In the later
category, her most recent research is on the use of foreign branding and the use of advertising in free-standing inserts.

Professor Drazen Prelec has focused his activities on the contemporary research in consumer behavior that is influenced by economic models and psychological concepts and theories. He is examining several problem areas of individual decision-making, all basic to our understanding of human action which illustrate how economic intuition and psychological reality clash in an interesting and scientifically productive way.

BEHAVIORAL AND POLICY SCIENCES (BPS)

The continuing changes in the global social, economic and political environment continue unabated and are likely to continue doing so. These shifts in the business environment reinforce the wisdom of the school’s decision to emphasize the three areas of Globalization, Technology and Change. The faculty in the BPS group contain a diverse set of social and behavioral disciplines which are of central importance to each of the School’s three areas of emphasis, none of which will yield to the insights of a single discipline or a single functional view. The result has been a very active and prolific year for the group along several dimensions:

Sloan School Re-focusing

In conducting an extensive evaluation of our curriculum, the BPS group made major changes in three of the core courses (Strategy, Organizational Processes, and Communications). The latter two were completely re-done and were evaluated by both students and faculty as being successful and effective innovations. The strategy core course continued to play a successful and important part in the students first year education.

Around twenty of the BPS faculty have active research projects with foreign universities or companies. This is an example of the resource base the School has developed that would both create greater visibility and would enhance the students’ learning. For example, a number of BPS faculty ran extensive seminars for the students in preparation for their trips to Korea, Japan, Mexico, and the C.I.S. As the faculty then joined the students on these trips, it provided an excellent opportunity for informal, yet in-depth, learning.

The School’s re-focusing also involved BPS in the creation of a new Masters Track in ‘Strategic Analysis and Consulting’. As consulting is one of the job areas which draws the largest number of Sloan graduates, it seemed useful to make special efforts to turn out a distinctive set of graduates by giving them a rich set of focused offerings which would include practice and exposure beyond normal course offerings. This has been put in place to start in 94/95.

On the administrative side of the group, substantial progress was made in the never ending task of ensuring we operate as efficiently and effectively as we can.

Research

While the emphasis in BPS is on globalization, technology and change, as areas of interest; underpinning this is the dominant need for high quality and significant research. Each individual faculty member continues the School’s long-standing tradition of publishing in high quality refereed journals. This year, despite the enormous effort spent in contributing to refocusing the School, the BPS group published over 90 articles and some 18 books. Several of the books won prizes or awards and the flow of all this material does much to contribute to the School’s academic standing.

One established activity, the International Center for the Research on Management of Technology (ICRMOT) initiated under the leadership of Tom Allen and led this year jointly by Ed Roberts and John Hauser (from the Marketing Group) manages to combine research in the traditional academic mode (over 110 working papers) with high visibility and impact on the business world. As businesses are an important client of the School, this center has been particularly significant as it has brought twelve major corporations (six whom are non-U.S.) into close and continuing contact with the School through seminars on campus, research sites for faculty and students and research presentations and discussion at company locations.

In the same spirit, the BPS group is playing a major part in a school-wide initiative (Inventing the 21st Century Organization) that is based on the premise that the turbulence in the business environment (social,
This will in turn lead to new organizational forms. The possibility of innovative ways of creating and producing useful work is given added emphasis by the continuing rapid evolution of all forms of Information Technology. The combination of all these forces portends exciting but wrenching changes in the business world as we have known it. A conference in the Spring of 1994 with four hundred attendees launched this collaborative research initiative and it is clear that the Sloan School and the BPS group can make major contributions to the clarification of the options, this will be one of our major research objectives in the years ahead.

Tom Allen finished manuscripts on Cad Systems and Engineering Performance as well as studying the influence of supervisory promotion and network location on the careers in a dual-ladder setting.

Deborah Ancona continued her focus on teams with special interests in the performance of top management teams.


John Carroll has continued his research on managing and organizing for safety in nuclear power plants.

Michael Cusumano developed a number of manuscripts and working papers in the general area of software engineering as well as continuing to do research work on product development in the automobile industry.

Mauro Guillen concentrated on examining management techniques as they are transported across borders.

Rebecca Henderson has examined radical innovation in several industries.

Thomas Kochan developed a number of papers on new strategies for human resource management with particular interests in understanding the mutual gains paradigm.

Don Lessard continued research on corporate risk management and commenced a new area of work on changing patterns of ownership and governance in European industry.

Richard Locke completed work on his study of local politics and industrial change in Italy, and commenced work on a study of American unions in transition.

Robert McKersie (with Dick Walton and Joel Cutcher-Gershenfeld) completed work on analysis of strategic associations.

Dan Nyhart developed a computer model to understand the approaches used by a large bank to internal negotiations.

William Ocasio continued his work on the dynamics of movement and control of chief executive officers.

Paul Osterman worked on a variety of projects relating to the performance of internal labor markets, with special attention to youth and problems of low income workers.

Michael Rappa has been especially interested in the role of scientists in emerging fields.

James Rebitzer has been examining some of the factors that lead to the working of long hours, especially on the part of professionals.

Ed Roberts has completed a working paper on the Strategic Management of Technology with emphasis on global benchmarking.

Mary Rowe from her perspective as ombudsperson has published a number of papers on diversity and related matters.
Ed Schein has spent most of his year analyzing the organizational culture of the Economic Board of Singapore.

Stephan Schrader has been especially interested in examining the interaction between R&D and the role for government and public policy.

Michael Scott Morton edited a volume on "Information Technology and the Corporation of the Future".

Maureen Scully focused on the implementation of ethics programs in the Defense Industry.

Robert Thomas continued his work on the interplay of technology and organizational design.

Marcie Tyre examined patterns of technological adaptation across a number of industries and countries.

James Utterback completed a manuscript on the Dynamics of Innovation.

Eric Von Hippel researched the process of "learning by doing" and the function of "sticky" information in the problem-solving process.

Joanne Yates continued work on the evolution of information systems and technologies in firms.

Nick Ziegler examined the role of elites in France and Germany and their impact on industrial performance.

**LEADERS FOR MANUFACTURING PROGRAM**

In 1993–94, two key transitions took place in the Leaders for Manufacturing (LFM) Program: (1) Stephen C. Graves, Professor of Management Science, succeeded LFM Management Co-director Thomas L. Magnanti, George Eastman Professor of Management Science. (2) Dr. Stephen A. Fairfield assumed full-time responsibilities as LFM Assistant Director for Operations, succeeding Marcia V. Chapman, Operations Manager.

Government funding through the Technology Reinvestment Program (TRP), effective 1 June 1994, will enable LFM to place up to three interns per year in small and medium-sized enterprises.

A progress report for the year on eight "products" designated by the LFM Operating Committee as essential to program success follows. Focuses were research, leadership development, and nationwide collaboration. The year's highlights in these areas are asterisked below.

**Continuous Improvement**

To document progress and improvement opportunities, the Leaders Program surveyed constituents this past year to issue a five-year report. To monitor significant data more frequently, LFM this year developed an operations report covering all aspects of the Leaders Program, with which to regularly update the Operating Committee and Governing Board.

**Collaboration**

The 13 industry partners during LFM's first five years remain Leaders partners, maintaining and building on their close working relationship with MIT. In 1994, internships continued to increase the partners' manufacturing competitiveness, sometimes dramatically. One partner company estimates, for example, that recommendations of one 1993–94 LFM internship will save it $82 million over a ten-year period.

The Leaders Program significantly changed its Governing Board meeting format this year to offer the governors more opportunity to provide direction for the program, interact with one another, and exchange ideas on major manufacturing issues. Meetings will now be hosted by the LFM governors themselves in a "round robin" of select partner facilities.
Graduate Careers
The Leaders Program supported 86 fellows in 1993–94, bringing the total number of LFM fellows since the program's inception to 257. Two students received Robert N. Noyce fellowships and three received fellowships from the National Science Foundation.

This past June, 46 LFM dual-degree fellows graduated. Of 43 fellows who had confirmed their plans in early June, 86 percent assumed positions in US manufacturing companies, choosing from an average of more than three job offers each. Most-cited reasons for job decisions had to do with growth potential, respect and recognition of recruits as individuals, and "good people fit."

Leaders graduates (now 181) organized and hosted for the first time this spring an off-campus workshop (in Seattle) for all LFM alumni/ae; 47 graduates attended.

From 209 total applications received this past spring, 52 were accepted; 44 students (all with work experience) enrolled. The new fellows average 27 years in age and 4.3 years in work experience. Included in the new class are four women, two members of minority groups, and 11 partner-sponsored students.

Though women and minority group members are encouraged to apply to the LFM Fellows Program, their numbers in the program have declined in recent years. This situation is being studied and a strategy is under development to reach these individuals nationwide. They will be targeted in special LFM Admissions mailings this year, for example, and closer connections will be forged between the Leaders Program and professional organizations established for women and minority group members.

Curricula
*A distinctive feature of the LFM Fellows Program curriculum is its effort to further the understanding of leadership in manufacturing. The subject is developed primarily through skill development, practice (especially during the internship), and reflection, with limited classroom work. Second-year students prepare cases based on their internships to teach classmates and first-year fellows, helping first-years prepare for the internship while refining the cases as potential teaching materials for other MIT courses.

Leadership activities start with a unique orientation ("The Universe Within") to LFM during the fellows' first four days on campus in June. It offers a broad, multidimensional and nontraditional overview of leadership, ranging from behavioral scientific research findings to dialogue exploring systems concepts, "thought worlds" characterizing organizations, and communication, learning, and values. An underlying hypothesis is that fundamental organizational change requires reconsideration of core assumptions and objectives. The intent is to create among the fellows a learning organization that constructively challenges conventional mental models.

Manufacturing Faculty
The Leaders Program actively involved 74 faculty and research staff in 1993–94. During this time period, four of the faculty were promoted, one of them gaining tenure.

*Interdisciplinary Research
Under direction of Drs. Eugene Meieran of Intel and Nils Muench of General Motors, more than 120 LFM industry partner and faculty researchers met this past year to define a collaborative research process. They identified nine programs as research imperatives that could significantly improve manufacturing performance. Most of the 46 short-term (internship) research projects and 36 long-term projects supported by the Leaders Program in 1993–94 are now categorized according to these nine research programs.

Criteria for selection of the research programs were importance to industry as well as faculty interest. Goals are to leverage research dollars, achieve synergies across diverse firms, facilitate collaborative research in "Big-M" Manufacturing, and obtain funding from external organizations.

Each research program consists of one or more technical groups led jointly by industry and MIT faculty, with representation from at least three LFM companies. The groups, which also offer "umbrellas" for both LFM interns and research assistants, are developing collaborative research projects.
To encourage more effective networking among many of the national organizations performing manufacturing research in the United States, Drs. Meieran and Muench and Dr. Douglas Braithwaite also compiled two directories: (1) *Leaders for Manufacturing Research Program Contacts* has been distributed to LFM partners involved in research; (2) *A Manufacturing Science and Technology Research Database of university-based programs, government agencies, industrial consortia, national associations, and foundations actively involved in manufacturing research* has been distributed to manufacturing engineers and managers in industry, universities, and government laboratories, agencies, and associations. In addition, LFM researchers now complete one-page “Research Sales Brochures” summarizing their work, categorizing it according to the nine research programs, and defining expected benefits.

The Leaders Program supported 36 graduate research assistants this past year, and the LFM Working Paper series now exceeds 400 titles.

**Implementation and Leadership**

*The LFM co-directors participated in nearly 50 visits with government and university leaders this past year, broadening dialogue for university/industry/government partnerships to improve manufacturing. The University of Michigan, California Polytechnic State University, and Pennsylvania State University have joined MIT in developing a National Manufacturing/University Coalition to advance a national agenda of revitalizing US manufacturing.*

The Leaders Program is also working with Worcester Polytechnic Institute (WPI) under a TRP grant to impact undergraduate education with LFM learnings.

**COMPUTER CENTER**

Sloan Computer Center student labs now offer 486 IBM and Dell systems, Macintosh PowerMac and Quadra systems, HP workstations and network connections for student PC and Mac laptop computers. Color printing, color and black/white scanning and laser printing are also available.

We are now using America Online as our electronic mail and conferencing system for Sloan Fellows, MOTs and LFM students. In addition to all the features of AOL, there are special screens for Sloan students. These screens contain student and faculty directories, newsletters, bulletin boards and chat rooms specific to Sloan programs. America Online is also being used for our Sloan Alumni News Network, and alumni are encouraged to sign up for AOL accounts to communicate with classmates, faculty and staff members, keep abreast of Sloan news and information, order working papers and other Sloan items, view the Sloan calendar, etc.

**AFFIRMATIVE ACTION**

The Sloan School is very committed to bringing more diversity across the entire matrix of the School. This commitment is reflected in the establishment of the Diversity and Community Committee, one of the first initiatives under the Deanship of Glen Urban.

We are also working on a number of strategies to increase the number of women and minorities into the community at the Sloan School:

- **Minority Student Program** - We held a special reception for prospective minority students for the Sloan Master's program.

- We plan to expand the network of individuals who might participate in our teaching and research activities at the School. This might be done by identifying organizations whose focus is to network women/minorities and then to establish a more direct liaison within that organization.

- We plan to followup with faculty to encourage the hiring of women and minorities into the faculty ranks.

- We plan to explore a more formal contract with higher education search firms that provide "feeder" candidates from the women and minority pools into our administrative positions.
We plan to explore a more formal relationship with a college or university that would be interested in a faculty liaison/student exchange program. The purpose of the interaction is to develop a more formal link that would allow us to expand the group of minorities who may have an interest in participating in our teaching and research program.

This year in our Master's Program 4.6% or 11 out of 238 were underrepresented minorities and 26% (60 out of 226) were women. In our doctoral program 25% or 23 out of 93 were women and 6% or 6 out of 93 were underrepresented minorities.

PERSONNEL CHANGES for 1993-94
Glen L. Urban, PhD in Management, was named Dean of the Sloan School of Management, replacing Lester C. Thurow, who stepped down June 30, 1993.

Paul M. Healy, PhD in Accounting, was named Deputy Dean, replacing Stephen C. Graves who stepped down effective August 30, 1993.

There were two promotions to full professor: Paul M. Healy (also named Deputy Dean) and Jeremy C. Stein, PhD in Economics.

James Utterback was transferred to Sloan School and promoted to full professor.

Tenure was granted to Michael Cusumano, PhD in Japanese History and East Asian Languages, and Lawrence Wein, PhD in Operations Research.

There were five promotions to Associate Professor: Steven Eppinger, PhD in Engineering; Rebecca Henderson, PhD in Economics; Richard Locke, PhD in Political Science; James Rebitzer, PhD in Economics; and Michael Rappa, PhD in Strategic Management and Organization.

Two new faculty for 1993-94 were: Ella L. Bell, PhD in Organizational Behavior, was Visiting Assistant Professor for 2 years and appointed as an Assistant Professor in the Behavioral and Policy Sciences Area. Ron Adiel, PhD in Accounting, from the Wharton School of Business was appointed as an Assistant Professor in the Economics, Finance and Accounting Area.

Seven faculty were named to Professorships: Thomas J. Allen, PhD in Management, was named to the Howard Johnson Chair; S. Lael Brainard, PhD in Economics, was named to the Mitsubishi Career Development Professor; Steven Eppinger (also promoted to Associate Professor) was named to the Nanyang Technological University Career Development Chairs; Marcie Tyre, DBA in Business Administration was named to the Standish Career Development Chair; Wanda Orlikowski, PhD in Information Systems was named to the Gordon Y. Billard Career Development Chair; Alwyn Young, PhD in Economics, was named to the Ford International Career Development Chair; and Lester C. Thurow, PhD in Economics, was named the Jerome and Dorothy Lemelson Professor of Management and Economics.

Sloan School had a number of visiting faculty and lecturers: Roger Huang, Professor of Finance from the Vanderbilt University; Barbara B. Jackson, Senior Lecturer, who is a consultant in Marketing; John Stopford, Professor of International Business from the London Business School; Robin A. Prager, Assistant Professor from the Owen Graduate School of Management at Vanderbilt University; Akshay Rao, Associate Professor from the Carlson School of Management of the University of Minnesota; Janice A. Klein, Visiting Associate Professor who came to us in 1991 from Harvard Business School; Don O. May, Assistant Professor from Loyola University, Chicago Graduate School of Business; Georgia Perakis, Assistant Professor from Brown University; John L. Akula, Visiting Lecturer from the Kennedy School of Business.

Change of Appointment: Ernst G. Frankel, PhD in Economics and DBA in Operations Management now holds a joint appointment with Electrical Engineering and Sloan.

Seven faculty were on sabbatical: Thomas J. Allen, Fall 1993; Arnoldo Hax; Stuart E. Madnick, Fall 1993; Paul Osterman; Nancy Rose; Thomas Stoker; and Lester Thurow.
Five faculty returned from sabbatical: Donald Lessard; James Orlin; Robert S. Pindyck; Thomas Malone; and Thomas J. Allen.

Eight faculty went on personal or professional leave: Andrew Alford; Chi-fu Huang; Chris Kemerer (spring); France Leclerc; Karl Ulrich; D. Eleanor Westney (spring); Alwyn Young; and J. Nicholas Ziegler.

Two faculty returned from personal or professional leave: Rebecca Henderson and Stephan Schrader.

Changes in Administration: Lawrence S. Abeln, MPhil in International Relations from the University of Cambridge in England joined the Sloan School as Director of Master's Alumni Relations. Elizabeth Martin, BA from the University of Massachusetts, joined the Sloan School as Program Manager for Special Executive Programs. Ilse K. Evans, MBA from Simmons College, joined the Sloan School as Director of Placement and Job Development.

Terminations included: Andrew W. Alford, Geoffrey M. Brooke, Chi-fu Huang, and Stephan Schrader.

EXTERNAL RELATIONS
This past fiscal year the Sloan School's cash revenue was $10,568,953 and, with Tang Center cash included the total amount of gifts was $12,692,093. The major new cash revenue for the school was received from Jerome and Dorothy Lemelson to establish a program fostering American invention and innovation. This $6,700,000 pledge supports: a national prize to be awarded to an individual demonstrating excellence and creativity in invention and/or innovation; a professorship; Ph.D. fellowships; student awards; and REPE, a series of educational activities investigating US competitive advantage, intellectual property rights, and entrepreneurial-related issues. Gifts totaling $2,587,500 were received from Jerome and Dorothy Lemelson in FY94 against their $6,700,000 pledge leaving a pledge balance of $4,112,500. In addition, the Lemelsons contributed $75,000 in FY94, in advance of making the $6.7 million dollar pledge, as seed money for the program.

The FY93 pledge payment from NTU came in after the FY93 books were closed. Accordingly, this fiscal year's pledge payments from NTU, totaling $3,490,000, reflects two FY94 gifts of $2,000,000 and $1,490,000. These payments are the last payment on a five year $10,000,000 pledge and terms for a second stage of the Sloan/NTU relationship, for a somewhat lesser amount, are in the process of being finalized.

Another significant gift came from Patrick J. McGovern, Jr. '59LI who made a final pledge payment of $442,679 toward the professorship in his name and pledged $500,000 towards the Abraham J. Siegel Chair. Additional major cash gifts received were $150,000 from CS Holding for doctoral fellowships and $149,980 from Istituto Nazionale delle Assicurazioni for the Franco Modigliani Professorship. In addition to this, another $110,174 was contributed to the Modigliani chair including $46,486 from Banca Commerciale Italiana.

The Tang Center building occupied much of the time of the development staff and we received a total of $2,123,140 in FY94 cash towards the building. Significant gifts received were: $1,000,000 pledge payment from the the Tang family; $300,000 from David Pun Chan '72LI; $200,000 from Lester C. Thurow; $200,000 from Kenneth W. S. Ting; $99,985 from Yoshitomi Pharmaceutical Industries Ltd.; and $75,000 from Alexander V. d'Arbeloff '49MG, who also contributed $25,000 for doctoral fellowships. The total amount of gifts and pledges for the Tang Center now stands at $6,439,848.

A significant priority for the school has been to increase the annual total of unrestricted revenue. In FY94 the unrestricted gift total was $643,740 up from $565,311 in FY93. Much of these increased totals are due to a combination of the Annual Fund and the Business Associates Programs which both continue to grow in the scope of their activities. Also, a significant pledge payment gift of $95,625 for unrestricted purposes was received from Sloan alumnus and current Wharton School Dean, Thomas P. Gerrity Jr. '63GM.
Comparisons between FY93 and FY94 cash revenue are as follows:

### FY93-FY94 Comparison Analysis

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<tr>
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<th>FY93 Totals</th>
<th>FY94 Totals</th>
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<tbody>
<tr>
<td>Expendable</td>
<td></td>
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<tr>
<td>Unrestricted</td>
<td>564,133</td>
<td>643,605</td>
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<tr>
<td>Fellowships</td>
<td>177,591</td>
<td>179,502</td>
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<td>Non-Fellowship Awards</td>
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<td>10,000</td>
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<tr>
<td>Chairs</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Restricted Resch.</td>
<td>2,061,402</td>
<td>1,967,436</td>
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<tr>
<td>Program Revenues</td>
<td>156,680</td>
<td>4,434,208*</td>
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<tr>
<td>Other</td>
<td>26,337</td>
<td>291,000</td>
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<tr>
<td><strong>Total Expendable</strong></td>
<td><strong>$2,986,143</strong></td>
<td><strong>$7,525,751</strong></td>
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| Endowment            |             |             |
| Unrestricted         | 20,263      | 9,088       |
| Fellowships          | 479,599     | 373,301     |
| Chairs               | 1,301,552   | 2,636,041   |
| Restricted Resch.    | 60,500      | 24,772      |
| Other                | 100         | -           |
| **Total Endowment**  | **$1,862,014** | **$3,043,202** |

**TOTALS**

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<tr>
<th></th>
<th>FY93 Totals</th>
<th>FY94 Totals</th>
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<tbody>
<tr>
<td>$4,848,157</td>
<td>$10,568,953</td>
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<tr>
<td>Tang Center for Mgt.</td>
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<td>$2,123,140</td>
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<tr>
<td><strong>TOTALS including Tang</strong></td>
<td><strong>$6,167,944</strong></td>
<td><strong>$12,692,093</strong></td>
</tr>
</tbody>
</table>

*Includes $3,490,000 from NTU

GLEN L. URBAN
Introduction

The School of Science at MIT continues to play a leadership role in science education and research both nationally and internationally. Our faculty received a broad array of honors and awards during the past year, the most notable being the receipt of the 1993 Nobel Prize for Medicine and Physiology by Phillip Sharp, Head of Biology. All of our graduate programs are ranked either first or second in the Nation. Of course, maintaining this high standard in the future will require continued dedication and diligence by all of the members of our community, especially in an era of diminishing resources.

Our education programs continue to evolve and improve in response to ever-changing conditions. The Minors in Science Program was formally inaugurated this autumn. In 1993-94, 105 students registered as Minors in Science, the largest numbers being in the departments of Biology and Chemistry. Biology was successfully introduced into the core curriculum in FY1994. Physics began organizing a major change in the structure of 8.01 with most of the teaching to take place in small sections of ~20 students. This will be introduced in FY95. EAPS is planning a revamping of its educational program, especially at the graduate level, with an emphasis on a systems approach.

In 1993 the School of Science established the "School of Science Teaching Prize for Graduate Education" to complement the prize for undergraduate education established by John Deutch in 1983. The first winner of this new award was Prof. Mehran Kardar of the Department of Physics. The 1994 winners were Victor Guillemin of Mathematics and Frank Solomon of Biology. The School of Science Teaching Prize for Undergraduate Education was won by Tom Greytak of Physics. Two School of Science faculty were chosen as MacVicar faculty fellows in FY94; they are Gene Brown of Biology and Rick Binzel of EAPS.

The quality of an academic enterprise such as the School of Science is determined primarily by the caliber of the faculty who make it up. Thus one of the highest priorities of the current administration in the School has been to support properly our existing outstanding faculty as well as recruiting to MIT exceptionally talented young educators and researchers. In 1993-94 nine new faculty joined the School as assistant professors; one additional faculty came as a full professor. Of these, two were minorities. We also have recruited nine new faculty who will join us as assistant professors together with one associate professor for 1994-95. Of these, one is a woman.

One of the principal issues which School of Science faculty and administration focused on during the previous year was new frontiers in research and education. It was decided that neuroscience represented an important endeavor which seemed poised for many important new discoveries. It was further agreed that significant expansion in this area within the School was called for. After some deliberation we concluded that the optimal strategy for the School of Science and MIT as a whole was that the Department of Brain and Cognitive Sciences should join the School of Science. We would then complement existing research in BCS with new programs in neurobiology as well as in other areas of cognitive and neuroscience overlapping mathematics, statistical physics and biochemistry. This organizational change was enthusiastically endorsed by virtually the entire community and, in FY1994 it was formally implemented with the entry of the Department of Brain and Cognitive Sciences into the School of Science. In April of 1994 we announced the establishment of the Center for Learning and Memory. This new Center which is joint between the Departments of Biology and Brain and Cognitive Sciences, will focus on the biological roots of learning and memory. The establishment of this center was made possible by a grant from the Sherman Fairchild Foundation. The first head of CLM is Professor Susumu Tonegawa of CCR/Biology.
In this brief prologue, we have not been able even to indicate many of the wonderful achievements of the School of Science faculty, students and administration in 1993-94. However, most of these are covered in the reports that follow.

**Academic Programs**

There were 848 undergraduates in the School of Science during the past academic year, a 9.56% increase from the previous year. The number of minority students at the undergraduate level changed as follows:

<table>
<thead>
<tr>
<th>Group</th>
<th>Previous Year</th>
<th>Current Year</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blacks</td>
<td>28</td>
<td>20</td>
<td>Decreased from 28 to 20 (28.57% decrease)</td>
</tr>
<tr>
<td>Hispanics</td>
<td>42</td>
<td>48</td>
<td>Increased from 42 to 48 (14.29% increase)</td>
</tr>
<tr>
<td>Native Americans</td>
<td>4</td>
<td>8</td>
<td>Increased from 4 to 8 (100% increase)</td>
</tr>
<tr>
<td>Asian Americans</td>
<td>170</td>
<td>216</td>
<td>Increased from 170 to 216 (27.06% increase)</td>
</tr>
</tbody>
</table>

The female undergraduate population increased from 287 to 336 (17.07%). Twenty-three percent of the Institute's upperclass undergraduates were enrolled in the School of Science.

Graduate enrollments in science increased from 1,054 to 1,119. The total enrollment represents 23 percent of the graduate population at MIT. The number of minority students at the graduate level changed as follows:

<table>
<thead>
<tr>
<th>Group</th>
<th>Previous Year</th>
<th>Current Year</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blacks</td>
<td>13</td>
<td>18</td>
<td>Increased from 13 to 18 (38.46% increase)</td>
</tr>
<tr>
<td>Hispanics</td>
<td>7</td>
<td>13</td>
<td>Increased from 7 to 13 (85.71% increase)</td>
</tr>
<tr>
<td>Native Americans</td>
<td>0</td>
<td>0</td>
<td>Remained at 0 (0% increase)</td>
</tr>
<tr>
<td>Asian Americans</td>
<td>36</td>
<td>42</td>
<td>Increased from 36 to 42 (16.67% increase)</td>
</tr>
</tbody>
</table>

The number of female graduate students increased from 265 to 306 (15.47%).

There were 273 faculty members in the School this past year. This represents an increase of 6.64% from the previous year. The undergraduate student-to-faculty ratio was 3 to 1, and the graduate student-to-faculty ratio was 4 to 1.

**Research Volume**

The FY94 research volume was $117 million, a 1% increase over the FY93 research volume.

ROBERT J. BIRGENEAU
INTRODUCTION

The Biology Department currently has 55 active faculty members of whom 13 are located in the Whitehead Institute, 11 are located in the Center for Cancer Research, three are joint appointees with the Department of Brain and Cognitive Sciences, one is joint with Chemistry and one is joint with the Department of Civil and Environmental Engineering. Including Emeriti faculty, four of the faculty are Nobel laureates, 20 are members of the National Academy of Sciences and 10 are investigators of the Howard Hughes Medical Institute. The department has a very strong international reputation in research and teaching and has been a leading contributor to the development and application of molecular biology.

EDUCATIONAL ACTIVITIES

Undergraduate Program

In the past year, the number of undergraduates registered as Biology majors was 300. In the Fall, the Office of the Registrar reported that more sophomores than ever before are majoring in biology. Increasing 60 percent, 120 sophomores declared biology as their major, compared to 75 students the previous year. The Bachelor of Sciences in Biology degree was awarded to 81 students this past year: 73 in the regular Course VII Program, eight in the VII-A Program. A number of Biology majors received awards in 1994. The 1994 Whitehead Undergraduate Prize, given to an undergraduate student(s) majoring in Biology, who shows outstanding promise for a career in biological research as demonstrated by involvement in research, course work and contributions to the MIT community, was awarded to Gregory Chin and Valerie Tan. The recipients of the 1993-1994 John L. Asinari Award were Javier Apfeld and Ranee Mehra in recognition of the best paper based on research done in a Project Lab or in the Undergraduate Research Opportunities Program (UROP) by a Biology major. Ranee Mehra also received honorable mention for the A. Parke and Ann L. Hodges Prize for outstanding undergraduate writing in a student's professional field. Valerie Tan was jointly named the winner of the Malcolm Kispert Award as the outstanding senior scholar/athlete of the year. Eugene F. Schuster received honorable mention for the Boit Manuscript Prize for drama. Tallessyn Z. Grenfell was awarded first prize for the Robert A. Boit Prizes for essays; Shane Crotty won second prize and Venkatesh L. Murthy received third prize. Thuchien Thi Nguyen was the winner of this year's Randolph G. Wei UROP Award given to the undergraduate who has made the most outstanding contribution in undergraduate research at the interface of the life sciences and engineering. The following students were elected to Phi Beta Kappa: Tracy Adams, Javier Apfeld, Gregory Y. Chin, John H.K. Chiu, Devang V. Kantesaria, Gregory M. Lubiniecki, Davey Q. Shih, Stephen C. Stroupe, Wai Thong Wong and Byungdoo Yi. Yi-Fen Chen was elected to Tau Beta Pi. The Robert de Friez Hunneman Prize to a 4th year student for outstanding scholarship in academics and research was awarded to Wai Thong Wong. Wen Hon Kao received a Public Service Center Fellowship for public service work done in conjunction with Cambridge Public Schools. Edward S. Darna Awards, honoring substantial contributions to the life of the theater at MIT, were presented to Michelle A. Starz and Eugene F. Schuster.

This past Fall core biology became a General Institute Requirement starting with the class of 1997. Three versions of the course were taught by some of the best lecturers in the department. All three core biology courses covered the common core material of biochemistry, genetics, molecular biology and cell biology.

Graduate Program

During the period from July 1, 1993 to June 30, 1994, 20 Ph.D. degrees were awarded in the Department; two Ph.D. degrees were awarded in the Joint Program in Biological Oceanography with the Woods Hole Oceanographic Institute (WHOI). The maximum number of Ph.D. candidates registered in the Department in 1993-1994 was 186, with another 31 in the Joint Program. The entering class in 1993, including 11 in the Joint Program, was 33. The class arriving in September, 1994 will be 50, including seven WHOI students.
One new subject was added to the graduate curriculum this past year, 7.85, Selected Topics in Cell Biology.

We are pleased that Professor Frank Solomon was recognized for his outstanding contributions to graduate teaching with the School of Science Graduate Teaching Prize.

RESEARCH

The research activities of the department are in the areas of biochemistry, genetics, microbiology, cell and developmental biology, immunology, neurobiology, and virology. The FY94 total direct cost of research in the department (including the Center for Cancer Research and the Whitehead Institute) was approximately $33 million ($13 million of that was at the Whitehead Institute). MIT overhead on the funding in the department and the Cancer Center was approximately $7.7 million. At a time of difficult research funding, the department has maintained its level of federal support.

There were many research achievements over the last year, too numerous to all be mentioned here. Research projects of all laboratories are described in the annual publication, Department of Biology Annual Report, available in the Biology Headquarters Office (68-132). There were, however, several significant advances in the areas of human health and disease. For example, cancer cells frequently become resistant to chemotherapy. Drs. Tyler Jacks and David Housman have discovered a new form of resistance to treatments such as x-rays and chemotherapy. This finding may make it possible to design more effective treatment for cancer. Dr. David Baltimore has continued research in the areas of AIDS. Recently his laboratory has shown that patients who are symptom-free can be stratified into two groups dependent upon the presence or absence of a low level of virus in their blood. Patients with circulating virus have a high probability of developing the immuno-deficiency causing AIDS within 2 years. Dr. Baltimore’s laboratory has also shown that a cellular factor important for HIV expression is not essential for normal cellular functions but is activated by general stress. This factor then becomes a good target for drug therapy. Dr. Susumu Tonegawa has discovered that inactivation of a gene for the brain receptor for the neurotransmitter dopamine gives rise to a mouse with Parkinson type traits. This neurotransmitter pathway is related to schizophrenia and addictive behavior in humans and this genetic model may offer insights into these problems. Dr. Tonegawa’s laboratory has also developed a new mouse system to study auto immunity, particularly type 1 diabetes. This is particularly exciting as approximately one in ten people suffer from some form of auto immunity. Dr. Hermann Steller has discovered a new gene controlling a cell’s ability to undergo programmed cell death. The appropriate death of cells is critical for almost all biological processes. Previously Dr. Robert Horvitz had shown that organisms have elaborate genetic programs to determine cell death. Dr. Carl Pabo’s laboratory has recently determined the atomic structure of an important protein bound to its target DNA. The protein controls expression of several genes such as those encoding immune antibodies. Surprisingly the protein binds to DNA in distinct parts. Dr. Alexander Rich’s laboratory has discovered a new type of protein that assembles into highly stable sheets. This small protein may be ideal material for covering surfaces on which cells must attach during wound healing.

PERSONNEL

Professor Richard Young has been promoted to full Professor effective July 1, 1994, and Professors Arthur Lander, Terry Orr-Weaver and Hermann Steller have been promoted to tenure.

Professor Peter Sorger joined the MIT faculty in January 1994. Professor Sorger’s laboratory studies the mechanisms that regulate the separation of chromosomes in the yeasts S. cerevisiae and S. pombe.

Professor Jacqueline Lees joined the faculty in April of 1994. Her laboratory, which is located in the Center for Cancer Research, studies the control of cell division and the role of the retinoblastoma protein encoded by a tumor suppressor gene.
We are pleased to report that three new faculty members have accepted positions in the Department.

Dr. Stephen Bell has accepted a position as Assistant Professor in the Department and will join the faculty this Fall. Dr. Bell’s research will focus on the initiation of DNA replication in eukaryotic cells. Dr. Bell received his Ph.D. in biochemistry from the University of California, Berkeley and is currently doing postdoctoral work at Cold Spring Harbor Laboratory.

Dr. Jianzhu Chen has accepted a position as Assistant Professor joint with the Department and the Center for Cancer Research and will assume his appointment in September 1994. Dr. Chen is an immunologist and studies B cell development. He received his Ph.D. from Stanford University and is currently a postdoctoral fellow at the Department of Genetics, Harvard Medical School and Children’s Hospital, Boston.

Dr. Matthew Wilson has accepted a secondary appointment as an Assistant Professor in the Department of Biology and a primary appointment in the Department of Brain and Cognitive Sciences. Dr. Wilson is the first new appointment to the Center for Learning and Memory and will move to MIT in September. Dr. Wilson has done unique work on the electrical pattern of activity in the hippocampus during spatial learning in rodents. He received his Ph.D. from California Institute of Technology and did postdoctoral work at the University of Arizona.

Dr. David Baltimore returned to MIT to assume the Ivan R. Cottrell Professorship and to establish his laboratory on the third floor of the new Biology Building. Dr. Baltimore will continue his research on AIDS, cancer and immunology.

The department revitalizes itself with the recruitment of new faculty and is continuing active searches to fill open positions in the department, in the Center for Cancer Research and the Whitehead Institute.

Honors and Awards to the Faculty

It is a pleasure to report the following honors and awards to Biology faculty during the past year:

Tania Baker was named an assistant investigator of the Howard Hughes Medical Institute.

David Baltimore was named the first Ivan R. Cottrell Professor of Molecular Biology and Immunology.

Gene Brown was named a MacVicar Faculty Fellow.

Arnold Demain was elected honorary foreign member of the Societe Francaise de Microbiologie and was also elected to the U.S. National Academy of Sciences.

Gerald R. Fink was the Gladstone Distinguished Lecturer in Cell Biology at the Gladstone Institute.

H. Robert Horvitz received the 1993 V.D. Mattia Award.

David Housman was elected to the U.S. National Academy of Sciences.

Tyler Jacks was named an assistant investigator of the Howard Hughes Medical Institute.

Peter Kim received the 1994 DuPont Merck Young Investigator Award of the Protein Society and the 1994 Eli Lilly Award in Biological Chemistry from the American Chemical Society.

Eric Lander received the 1993 Herbert W. Dickerman Award from the New York Department of Health.

Phillip Sharp received the 1993 Nobel Prize in Physiology or Medicine for his discovery of split genes.

Susumu Tonegawa was named the first Amgen, Inc. Professor.

Annamaria Torriani-Gorini was elected honorary foreign member of the French Society of Microbiology.

Richard Young received the 1994 Chiron Corporation Biotechnology Award by the American Society of Microbiology.
Establishment of the Center for Learning and Memory

The Center for Learning and Memory was established by The Sherman Fairchild Foundation with a $5 million gift to MIT. Dr. Susumu Tonegawa was appointed the first director of the center. The center's research efforts will focus on the biology of learning in the cortex, on parallels between developmental and learning-related brain changes, and on the role of biologically active molecules in learning and memory. The faculty in the center will have joint appointments in the Department of Biology and in the Department of Brain and Cognitive Sciences.

Building Biology

On May 1st, the Department began moving into the new Biology building and by June 8th all faculty with primary appointments in the Department and not located in the Center for Cancer Research or in the Whitehead Institute had relocated to building 68. The building provides new state-of-the-art facilities, including electricity, and has a full range of laboratory and ancillary spaces for the study and research of biology, microbiology, biochemistry, transgenics and molecular biology. We are grateful to Mr. Frank Lawton, MIT Project Manager, for his untiring efforts in overseeing the construction of the new building.

On June 7th the Whitehead Institute broke ground for its new research wing which will add approximately 76,000 gross square feet. The new six story wing will provide state-of-the-art facilities to extend Whitehead's research programs in transgenic sciences, infectious disease research and structural biology.

PHILLIP A. SHARP
Research in the Department of Brain and Cognitive Science integrates diverse approaches to the understanding of brain functions. There are three primary areas of research: neurobiology, systems neuroscience and computation, and cognitive science, all with an increasingly strong emphasis on learning and memory.

RESEARCH

Neurobiology

Faculty members in this area are involved in a variety of studies ranging from the development of the nervous system to the cellular and molecular basis of memory, and to the understanding of neurological disorders such as Parkinson's and Alzheimer's diseases.

Among the research accomplishments of the past year are the developmental studies of Prof. Hermann Steller. Prof. Steller has identified in the fruit fly *Drosophila* mutants which affect the generation of specific neurons, the formation of proper neuronal connections, and the elimination of cells by programmed cell death. He has cloned and molecularly characterized several of the corresponding genes. Specifically, his work has revealed that *Drosophila* photoreceptor axons rely on positional guidance cues for establishing proper retinotopic maps. In an important series of novel studies, he has identified a *Drosophila* cell death gene, *reaper*, which plays a central control function for the initiation of programmed cell death. He has found that multiple signaling pathways for the induction of cell death converge onto the *reaper* gene, suggesting that all natural cell deaths in *Drosophila* occur by one common pathway.

Imaging the activity of populations of neurons in the cerebral cortex is another new area of research. Prof. Mriganka Sur has used optical imaging techniques to show that neurons of the primary visual cortex are tuned to gratings at particular orientations.

Prof. Richard Wurtman and collaborators have discovered that the hormone melatonin, which normally is secreted at night time, controls sleep. When very low doses are administered during the daylight hours to normal subjects, they fall asleep much more rapidly than when given a placebo. This sleep includes periods of rapid eye movement which is generally suppressed by hypnotic drugs. This discovery suggests that very low oral doses of melatonin may become a useful drug for the treatment of insomnia, particularly that associated with inadequate nocturnal melatonin secretion.

In another important study, Prof. Ann Graybiel has shown, in collaboration with Profs. Toshihiko Aosaki and Minoru Kimura, that there are specific cellular changes in the basal ganglia during sensorimotor learning in behaving monkeys. They demonstrated that the dopamine-containing microstriatal tract is necessary for the expression of learned neural responsiveness. They also showed that dopaminergic mechanisms in the striatum can lead to dramatic long-term changes in the expression of transcription factors thought to be critical gene products involved in the regulation of gene expression.
Systems Neuroscience and Computation
Faculty members in this area have focused on the study of information processing in vision and motor control. Prof. Emilio Bizzi, in collaboration with Drs. Ferdinando Mussa-Ivaldi and Reza Shadmehr, has investigated how the central nervous system learns to control movements in different dynamical conditions, and how this learned behavior is represented. These observations ruled out the hypothesis that motor learning is constructed via composition of a lock-up table. It appears that subjects learned new motor skills by a combination of computational elements whose output was broadly tuned across the motor state space.

Several interesting results have been obtained by Prof. Tomaso Poggio. His theoretical work suggested that 3-dimensional (3D) object recognition is view-based (the views represent the examples used for training the recognition module) without any need for an explicit, object-centered model. Recent simulations have confirmed that the view-based scheme is plausible in terms of performance. In addition, studies in humans showed results compatible with the theory. Neurophysiological experiments conducted with Dr. Nikos Logothetis at Baylor, have demonstrated the existence of cells in the temporal lobe of monkeys that are specifically tuned to views of the 3D objects used in training, with the properties predicted by the model. Combining theory with physiology has provided for the first time a means of characterizing in a quantitative way the neural mechanisms underlying visual recognition of 3D objects.

Cognitive Science
Noteworthy achievements during the past year have been in the area of development of language. Prof. Kenneth Wexler mounted major theoretical investigations in the computational theory of language learning (parameter-setting), in particular providing the first theory which shows how parameters can actually be set in learning.

Prof. Steven Pinker's publication of The Language Instinct, a popular science book which explains all aspects of language in a biological framework, has been a great success. There have been dozens of rave reviews and the book has been on the Boston Globe best seller list for several months (reading #2 at one point), and #1 on the Montreal Gazette list.

Prof. Michael Jordan has developed a statistical framework for learning in modular and hierarchical systems, which allowed him to analyze a variety of learning algorithms. In addition, he has developed models that are very important in understanding sensory-motor transformations. In particular, Jordan has focused on the way in which these transformations adapt to reflect changes in the environment.

FUNDING HIGHLIGHTS
Center for Learning and Memory
This new Center will be established jointly with the Department of Biology, thanks to a five year five million dollar grant from a private foundation. The Center will focus on the biological roots of learning and memory, which have largely been unexplored. An understanding of how information is processed and stored in the brain could yield major benefits in terms of human health, and also has the
potential to lead to major improvements in artificial intelligence systems. It is anticipated that there will be very highly productive collaborations with computer scientists, mathematicians, chemists and physicists, and especially with the Artificial Intelligence Lab and the Department of Brain and Cognitive Sciences' Center for Biological and Computational Learning.

EDUCATION
Graduate
Graduate students successfully competed for NSF and Howard Hughes fellowships, bringing two more of these prestigious awards to the department. Our nine new Ph.D.s will be moving on to postdoctoral or faculty positions, or medical training.

Joint programs with Harvard have been implemented in the form of a course offered by Prof. Pinker and Harvard Prof. Marc Hauser on the evolution of cognition. Students from BCS have taken the initiative and formed a discussion club on vision from perceptual, physiological, and computational perspectives. Participants are from MIT's Media and AI Labs, BCS, and Harvard's Psychology Department. There is also a new journal club in the area of Brain and Language, which is a collaborative effort with students from the Department of Linguistics and Philosophy.

Undergraduate
Following three years of an extraordinary rise in the number of undergraduate majors (from 15 to 60), we anticipate a modest increase during the coming academic year.

Several changes in curriculum were instituted, including the introduction of two new subjects: the Neural Basis of Motor Control, and the Neural Basis of Vision and Audition, and a major in the neurosciences is in the development stage.

FACULTY AWARDS AND ACTIVITIES
Individual members of the faculty have been extremely productive and have received recognition by the Institute and outside foundations.

Edward Adelson - Appointed to the editorial board at Vision Research
Ann Graybiel - Gave the John D. French Lecture at the UCLA Brain Research Institute
Gave the Boston Area Neuroscience Lecture at Boston University
Steven Pinker - Keynote address at the Society for Neuroscience
Keynote address at the Society for Cognitive Neuroscience
Gerald Schneider - Appointed to the NIMH Board of Scientific Counselors for review of the Clinical Brain Disorders Branch of the NIMH Neuroscience Center at St. Elizabeth's Hospital, Washington D.C.
Mriganka Sur - Gave the Institute Lecture at the Indian Institute of Technology in January

EMILIO BIZZI, M.D.
Chairman
INTRODUCTION
In the 1993/94 academic year, the Chemistry Department continued its strong programs in undergraduate and graduate education and research. The department currently has 34 active faculty, approximately 90 postdoctoral researchers, 250 graduate students and 120 undergraduate majors.

ACTIVITIES OF THE DEPARTMENT
The MIT Chemistry Department has initiated a Traineeship Program in the Chemistry of the Environment. Increasing numbers of students are expressing an interest in this area, which this program is designed to accommodate. A group of nine faculty in physical, inorganic, and chemical toxicology are joining in a coordinated study of the production, dispersion, and removal of chemical species in the natural environment, and their interactions with biological systems. Among the topics to be addressed are chemical processes in the stratosphere; detection of trace atmospheric pollutants; spectroscopy of free radicals found in combustion; synthesis of improved materials for fuel cells and catalytic converters; biochemical studies of methanotrophic bacteria; molecular biology of environmental carcinogens; and theoretical analyses of pollutant diffusion in the atmosphere.

In the spring of 1994, the department offered a Seminar in Environmental Chemistry, intended for graduate trainees in this program and open to other interested graduate students and advanced undergraduates. The seminar addressed technical, economic, political, and environmental aspects of problems involving both chemistry and society. Lectures examined case studies in the application of chemical technology to societal problems, such as effects of human activity on the atmosphere and the oceans, environmentally benign chemical processing, and toxic waste remediation. Experts from industry, government, and other academic departments participated in the seminar, so that the trainees were exposed to a wide range of views about how society should deal with the interaction between chemical technology and the environment. The seminar gave trainees from individual research groups that address widely different aspects of chemistry some common ground for thinking about environmental issues, and provided an important link to other environmental science and engineering programs at MIT.

This past winter there was an extensive article in Science/Technology regarding Professor Julius Rebek’s research on "hollow, spherical dimeric complex self-assembles via hydrogen bonding".

HONORS AND AWARDS
Prof. Mouni G. Bawendi was selected as an Alfred P. Sloan Research Fellow. This is an extraordinarily competitive award, involving nominations for most of the very best scientists of his generation from around the country. Also this past year, Prof. Bawendi was awarded the Graduate Award by the Graduate Student Council.

Dr. Catherine Costello, Associate Director of the Mass Spectrometry Facility, has accepted an invitation to serve as a member of the Physiological Chemistry Study Section, Division of Research Grants. Members are selected on the basis of their demonstrated competence and achievement in their scientific discipline as evidenced by the quality of research accomplishments, publications in scientific journals, and other significant scientific activities, achievements and honors.

Professor Rick L. Danheiser was honored for "pioneering research in the development of new methods for organic synthesis" by the American Association for the Advancement of Science.

Professor Gregory C. Fu was awarded the Camille and Henry Dreyfus New Faculty Award for 1993. In addition, Professor Fu was awarded a NYI fellowship, one of only twenty young scientists to be so honored this year.

Professor Alexander Klibanov received the 1993 Biotechnology Divisional Lectureship Award from the Institute of Food Technologists for pioneering research on the unusual properties of enzymes in non-aqueous solvents. He delivered his award lecture at the association’s annual meeting last fall.

Professor Peter Lansbury was selected to present the 1994 Paul Ehrlich Lecture at the 13th International Symposium of Medicinal Chemistry. This distinction was bestowed by the Paul Neumann Association for Scientific Research, a non-profit society created by Hoechst. The Paul Ehrlich lecture recognizes an outstanding contribution in the field of Medicinal Chemistry. Peter’s lecture involved the molecular mechanism of amyloid formation and was delivered in September in Paris.

Professor Stephen Lippard was selected to receive the 1994 American Chemical Society Award for distinguished Service in the Advancement of Inorganic Chemistry sponsored by Mallinckrodt Specialty Chemicals Company.
Professor Julius Rebek was elected to the National Academy of Sciences.

Professor Scott Virgil received the 1994 Pfizer New Faculty Award.

PERSONNEL
This past fall Professor Hanno zur Loye was promoted to associate professor without tenure.

Two new faculty members were appointed on July 1, 1993. Professor Christopher C. Cummins, a graduate student of Professor Dick Schrock's of the chemistry department, and Professor Gregory C. Fu who received his Ph.D. with Professor Evans at Harvard in 1991.

Professor Glenn Berchtold retired on June 30, 1994 after 34 years of dedicated service in the chemistry department. He will be sorely missed.

Ms. Melinda Cerny, our undergraduate supervisor, was promoted to coordinator of education in the Chemistry department beginning July 1, 1993. In her new position, she has the responsibility for administering all undergraduate and graduate subjects, teaching assistant training and support, the majors and minors programs, and provide support for the students and faculty.

DISTINGUISHED VISITORS
The Chemistry Department was privileged to host six distinguished scientists in endowed lectureships during the past academic year. Prof. Robert Grubbs, Cal Tech, was the Karl Pfister Visiting Professor in Organic Chemistry in April, 1994. Prof. Rudolph Marcus, Cal Tech, was an A.D. Little Lecturer in Physical Chemistry in April, 1994. Professor Karl Wieghardt, Ruhr-Universitat Bochum, was an A.D. Little Lecturer in Inorganic Chemistry in February, 1994. Prof. Thomas Cech, University of Colorado, was the T.Y. Shen Visiting Professor in April, 1994. Professor Larry Overman, University of California, was the George Büchi Lecturer in October, 1993. Prof. Clark Still, Columbia University, was the Procter & Gamble Visiting Professor in March 1994.

STUDENT ACTIVITIES
In the Fall of 1993 the Department admitted 58 students to the graduate program. The Department awarded 3 M.S. degrees and 51 PhD degrees this year.

The Senior Recognition Dinner was held on May 4, 1994 at which several undergraduates received awards. Jacquin C. Niles and Thomas E. Wilhelm received the Alpha Chi Sigma Award for achievement in research, scholarship and service to the department. Carmen M. Barnes, Jacquin Niles, and Alice Song received the Merck Index Award for outstanding scholarship. Carmen Barnes and Maki Inada received the Department of Chemistry Undergraduate Research Award for outstanding research in the field of chemistry by an undergraduate. Jason Greenwald, Elizabeth Kujawinski, and Samuel Nadler received the Department of Chemistry Undergraduate Teaching Award for outstanding teaching in the field of chemistry by an undergraduate. Jacquin Niles received the American Institute of Chemists Foundation Award for outstanding achievement, ability, leadership, and character.

Mr. Jonathan Bloch, a student of Prof. Field's, was selected by the New England Section of the Society for applied Spectroscopy as the second place winner of the 1994 Local Section Student Award. Ms. Martha Rook, a second year student in Prof. Jamie Williamson's group was awarded the first Texaco graduate fellowship.

ROBERT J. SILBEBY
INTRODUCTION

The Department of Earth, Atmospheric and Planetary Sciences (EAPS) comprises 40 faculty (including one with a primary appointment in Civil and Environmental Engineering), 73 research and support staff, and 183 graduate students. The Department is administered through five disciplinary groups: Geophysics, Geology and Geochemistry, Oceanography, Atmospheric Science and Planetary Science. There is no formal division between these fields, and the interdisciplinary nature of Department activities makes EAPS one of the broadest and best integrated earth science organizations in the world. Overlaying these disciplinary groups are several inter- and intra-departmental organizations, including the Earth Resources Laboratory (ERL), the Center for Meteorology and Physical Oceanography (CMPO) and the Center for Global Change Science (CGCS). EAPS is a major participant in the Joint Program in Oceanography with the Woods Hole Oceanographic Institution (WHOI), the Joint Program in the Science and Policy of Global Change, and the Center for Space Research (CSR).

FACULTY

One full professor was appointed to the faculty this year. Professor Frank Dale Morgan received his B.S. and M.S. from the University of the West Indies, and his Ph.D. in geophysics from MIT in 1981. His expertise spans a number of areas in geophysics, including rock properties, seismology, electromagnetic studies, and inverse problems. The main emphasis of his current research is on electrical properties of rocks and rock-fluid interactions.

On July 1, 1994, Dr. Richard Binzel, a planetary scientist, was promoted to Associate Professor with tenure. Dr. Edmund Chang was appointed as Assistant Professor of Meteorology on July 1, 1994. He received his Ph.D. from Princeton University in 1993 and is an expert on extratropical cyclogenesis and numerical modeling of atmospheric dynamics.

Dr. Douglas Burbank was the Crosby Distinguished Lecturer for the 1993-94 academic year. He is a professor in the Department of Geological Sciences at the University of Southern California and an expert in geomorphology and active tectonics.

The EAPS community was saddened by the untimely death of Professor Roger G. Burns, a noted mineralogist, on January 7, 1994. He began as a professor at MIT in 1970 and was the author of the influential book, *Mineralogical Applications of Crystal Field Theory*, which was recently issued in its second edition. Professor Emeritus Robert R. Shrock, head of Course XII from 1949 to 1965, passed away on June 22, 1993, at the age of 88. Under his direction, the EAPS program was expanded from classical geology to one that included the rapidly developing disciplines of geophysics, geochemistry and oceanography.

HONORS

Professor Jack Wisdom was awarded a MacArthur Fellowship, and Professor Tim Grove received the Bowen Award of the American Geophysical Union. Professor Edward Boyle was elected as an AGU fellow, and Professor Richard Lindzen was elected to the Norwegian Academy of Science and Letters. Professor Richard Binzel received the MacVicar Faculty Fellowship, the second EAPS faculty member to be so honored. Professor Paola Malanotte-Rizzoli received the Editor's Award of the American Meteorological Society.

Career Development Chairs were awarded to three assistant professors: the Kerr-McGee Chair to Dr. Chris Marone, an experimental geophysicist whose research focuses on understanding rock deformation processes and their implications for earthquake dynamics; the Cecil and Ida Green Chair to Dr. Maureen Raymo, a paleoclimatologist who uses geological information to investigate climate variations over time scales from thousands to millions of years; and the new Victor P. Starr Chair to Dr. Jochem Marotzke, a physical oceanographer who applies numerical modeling to the study of large-scale ocean circulation and its role in the climate system.

EDUCATIONAL ACTIVITIES

Undergraduate Program

EAPS has undertaken a series of initiatives to improve its undergraduate program and to increase the participation of EAPS faculty in undergraduate teaching across the Institute. They include a new, integrated core curriculum, new subjects in environmental science, the development of a minors program, a two-fold increase in the number of Freshman Advising Seminars, and a large expansion of the IAP program, with priority given to for-credit IAP subjects. Emphasis continues to be placed on EAPS participation in the UROP program, which has always been substantial.

In FY94, EAPS opened a new teaching facility on the third floor of Bldg. 54, comprising two new classrooms, a teaching laboratory, a sample storage and preparation room, and an academic computing laboratory. The classrooms and teaching laboratory have interconnected 35-in. digital monitors and audio-visual systems, which allow maximum flexibility when
doing computer-based teaching, broadcasting to Woods Hole over the MIT/WHOI microwave link, or using the campus cable-TV network.

Graduate Program

Nearly all of the EAPS graduate students (98%) are working towards a Ph.D. degree. In FY94, 104 graduate students were registered in the Department (Course 12), and another 79 were registered in the MIT-WHOI Joint Program (Course 12W). The Department awarded a total of 26 Ph.D. degrees and 7 S.M. degrees.

The study of complex geosystems has become a major force towards integration of the earth sciences, and this emerging synthesis provides a fresh basis for reexamining the EAPS graduate program. The current EAPS curriculum, like the Department itself, is an historical amalgamation of disciplines with very different educational research traditions, but all focused on preparing students for careers in basic research. The number of EAPS graduate students has held steady for the last thirteen years; applicants are among the best in the national and international pools, and they accept EAPS offers at a very high rate. Recent doctorates have been successful in securing good jobs. But the demand for Ph.D.'s in narrow areas of specialization is diminishing, while the need for scientists capable of dealing with problems in a broad, systems-oriented context is growing rapidly. This is especially true in disciplines that address environmental issues and ecosystem change. In response, EAPS is developing graduate subjects that teach disciplinary topics in the context of integrated approaches to geosystems. Mechanisms are also being sought to allow graduate students to broaden their education beyond the current requirements of course work and project-oriented Ph.D. research, including opportunities for involvement in policy-related aspects of geoscience and participation in cooperative programs with industry.

CURRENT RESEARCH

Atmospheric Science

Professor Kerry Emanuel continues to work on the control of atmospheric water vapor by cumulus convection, a key element in the greenhouse feedback problem. He has developed a model of the response of large-scale circulations to trace-gas variations. This work suggests that this response constitutes a strong negative feedback in the climate system that is inadequately handled in global climate models. He and his students continue to explore various facets of hurricanes, including genesis and intensity control through interaction with the ocean. Professor Richard Lindzen found that orbital variations can induce very large changes in the flux of heat from the tropics to high latitudes, and that these changes can force 100,000-year cycles of glaciation, similar to those observed in the geologic record. Professor Newell's group has found that the filaments of atmospheric water vapor, termed atmospheric rivers, are sometimes entrained into atmospheric cyclones, which then deepen very rapidly. His group participated in a NASA experiment in the western Pacific to measure about 50 atmospheric trace constituents, including pollutants from Asian air masses, and to provide meteorological support for Space Shuttle experiments. Professor Alan Plumb and colleagues are continuing their research into transport processes in the stratosphere and their influence on the ozone depletion problem. They have developed and applied a technique for modeling the fine-scale mixing processes in the winter stratosphere and have developed a conceptual model of global transport that is being widely used in the interpretation of in-situ measurements. Professor Peter Stone, in collaboration with Professor Jochem Marotzke, has investigated the behavior of the coupled atmosphere-ocean system to determine what is needed to model atmosphere-ocean interactions accurately. One important finding is that the conventional method used for tuning coupled models to reproduce the current climate can seriously prejudice the model's sensitivity to climate change.

Professor Mario Molina and his students have investigated the mechanism of formation of polar stratospheric clouds. They showed that at low temperatures significant amounts of nitric acid may be incorporated into liquid cloud particles, and that these particles freeze over Antarctica, but do not always freeze in the Arctic stratosphere. Nevertheless, their laboratory results indicate that the cold, liquid particles are as efficient as ice in the catalytic activation of chlorine, which leads to high-latitude ozone depletion. Professor Ronald Prinn and his colleagues in the Advanced Global Atmospheric Gases Experiment have determined from their global measurement network that the atmospheric concentrations of CFC13 are actually decreasing for the first time since their introduction 60 years ago. The concentrations of CF2Cl2, the other major chlorofluorocarbon, are still increasing, but the total global emission of this gas is continuing to decrease substantially. These results verify that provisions of the Montreal Protocol, and its follow-ons designed to protect the ozone layer, are having the desired effects.

Oceanography

Professor Edward Boyle's group completed construction and initial field testing of a moored in-situ trace element sampling device, for use in studying rapidly variable chemical properties in the ocean. He also has achieved analysis of single-specimen benthic foraminifera for Cd (-0.1 ppm in 50 µg specimen), a technique that provides key information in the reconstruction of deep ocean chemistry and circulation patterns. A survey of past deep water characteristics suggests that a major source of bottom water originated in the Indian sector of the Antarctic Ocean during the last glaciation. Professor John Edmond's work on the geochemistry of Siberian rivers continues with a transit of the entire Lena from the headwaters north of Lake Baikal to the Arctic Ocean. A new model was developed for the chemistry of submarine hot springs, involving the mixing of a brine, its "vapor" phase, and seawater. Edmond's work on the weathering cycle indicates that the present, natural atmospheric pCO2 level is at a kinetic minimum controlled by mountain building and that it is this recent geological activity that triggered the Ice Age. Professor Maureen Raymo established a stable isotope mass spectrometer lab and continued her research into the causes of past climate change. She and her colleagues recently showed that warm periods three million years ago had significantly lower atmospheric CO2 levels than had been predicted by climate modelers.
In physical oceanography, Professor Jochem Marotzke has concentrated on theoretical studies of large-scale interactions between the atmosphere and the ocean’s thermohaline circulation. In collaboration with Professor Peter Stone, he has demonstrated the importance of the ocean/land area ratio in determining how strongly the atmosphere controls ocean surface temperature. From a theoretical model, a new flux adjustment scheme was derived that may ensure not only the correct mean state, but also correct stability and sensitivities of a coupled ocean-atmosphere system. Much of the effort of Professor John Marshall and his collaborators has been devoted to the development of a state-of-the-art ocean circulation model designed to exploit the new generation of massively parallel computers; a close collaboration with computer scientists in the Laboratory for Computer Science has been forged. His studies of oceanic convection have culminated in the planning of a large multinational, sea-going experiment to observe convection in the Labrador Sea in the winter of 1996-1997. Professor Paolo Mazzotti and her collaborators have been modeling the ocean general circulation with emphasis on the assimilation of different datasets in the Gulf Stream System, the North Atlantic Ocean, and the Mediterranean Sea. In addition to studying the physics of vortices and jets in atmospheres and oceans, Professor Glenn Flierl and his colleagues are exploring the coupling between the physical dynamics and the biology of the sea, including the seasonal cycles in the upper waters, the mesoscale eddies, and the large scale circulations. As part of this study, techniques have been developed for reducing very complex biological ecosystem or species models to their essential components. The remarkable data sets from the TOPEX/POSEIDON altimetry mission have allowed Professor Carl Wunsch and his colleagues to study for the first time the behavior of ocean circulation over time spans of a few days. The data open the door to the possibility of modeling of the general circulation of the oceans as a fully turbulent fluid.

Geology and Geochemistry

Professors Sam Bowring and John Grotzinger, using precise age-dating of carefully studied rock formations in Siberia and Namibia, have shown that the Cambrian biological explosion took place in less than 10 million years. Bowring and his research group are also developing models for the evolution of continental crust and lithospheric mantle. They have demonstrated that the Acasta gneisses preserve a unique record of early Archean crustal evolution, manifested in a wide spectrum of initial Nd isotopic compositions not observed in other Archean cratons. Bowring interprets these data to indicate that very early in earth history, the entire planet differentiated into a crust, mantle, and core and that the chemical evolution of the mantle since that time reflects recycling of continental crust and lithospheric mantle back into the mantle. Professor Grotzinger’s additional research is directed at understanding the composition of the earth’s early ocean and atmosphere, and on the environmental setting of early metazoan evolution; field work is being conducted in northern Canada, Siberia, and southern Africa. He is collaborating with Professor Dan Rothman to characterize several different dynamical systems in sedimentary geology. Professor Fred Frey, in collaboration with French and Belgian colleagues, has been determining the origin and evolution of the Kerguelen mantle plume, a thermal and compositional anomaly in the earth’s mantle that has influenced the formation of the eastern Indian Ocean seafloor for 130 m.y. Their studies of Kerguelen lavas indicate that the origin and temporal evolution of this plume is very different from that of Hawaii. Professor Tim Grove has been studying the conditions of formation of komatiite magmas, a unique igneous rock type generated exclusively during the first 2 billion years of earth history. Reevaluation of the 3.49 Ga Barberton Mountain komatiites in South Africa indicates that the komatiite melts may have formed within a temperature range similar to that present in the modern mantle, and that komatiite magma melted significant amounts of dissolved H₂O, which may record degassing of volatiles inherited during accretion.

Professor Kip Hodges has concentrated on high-resolution dating of deformational and thermal processes in orogenic settings. ⁴⁰Ar/³⁹Ar geochronologic data from north-central Nepal imply that the Tibetan Plateau was established before 14 Ma, at least 6 million years prior to a dramatic climate change previously attributed to plateau uplift. He and his students have documented the first Ar diffusive loss profiles in micas and demonstrated the power of high-resolution laser mapping of rare-gas isotopic distributions in minerals for studying diffusion processes, mineral/fluid interactions, and the thermal evolution of Earth materials. Professor Clark Burchfiel is continuing field studies in several areas of China to understand the development of the Tibetan Plateau and eastern China extending to the South China Sea. He and Dr. Robert King have established a geodetic network of 31 Global Positioning System (GPS) stations centered in the eastern part of the Tibetan Plateau to provide precise data on active motions in Sichuan and western Yunnan. Senior Research Scientist Peter Molnar is working with Dr. Alan Gillespie of the University of Washington on a synthesis of timing of glacial advances in alpine settings. They have shown that, in the vast majority of cases, alpine glaciers reached their maximum extents well before the last global maximum about 20,000 years ago, which substantially lowers the rate of geological activity (e.g., fault slip rates) inferred from glacial morphology assuming these maxima coincided. Professor Leigh Royden’s work focuses on the degree of coupling between crustal deformation and mantle motions, particularly in the region of the Tibetan plateau. Progress to date suggests that the Indian lithosphere may underlie nearly all of the Tibetan plateau, and that surface deformation of the plateau is almost completely decoupled from motions in the mantle. Professor John Southard’s experiments in large laboratory channels at MIT and at the University of Minnesota are aimed at understanding the lateral and downstream segregation of sediment sizes in rivers; he is also continuing experiments in a gigantic oscillatory-flow duct to study the sedimentary structures produced during deposition of sand beds by storms in the shallow ocean.

Geophysics

Professor Chris Marone continued his research on the frictional properties of rock and the mechanics of earthquakes. His experiments on rough rock surfaces show that the currently accepted model for the critical slip distance for seismic faulting is inadequate. He has teamed up with USGS seismologists to study of variations in rupture properties for a series of repeating earthquakes, which show that the stress drop increases with recurrence interval, in agreement with predictions from laboratory
friction experiments. Interestingly, the events also imply that rupture duration decreases with recurrence interval, which is not predicted by current models. Professor Brian Evans and coworkers are studying the effect of rigid inclusions on the mechanical properties of rocks. By analogy with theories developed for metal matrix composites, they are modeling the evolution of rock strength during large strains, as might be observed in mylonitic zones in the Earth. Professor Dan Rothman and his students are studying dynamical and geometrical aspects of solid-fluid and fluid-fluid interfaces in geophysical and geological systems. Studies have included the development of a physical theory to explain the geometry of pore surfaces in sedimentary rocks, a geomorphological study of submarine canyons and their relation to turbidite sedimentation, and several studies related to the dynamics of interfaces in multiphase fluids, with emphasis on flow through porous media.

Professor Tom Herring has measured the changes in Earth rotation due to tidally induced ocean currents and has investigated the coupling of between the solid-inner core and fluid-outter core; his results suggest that these inner and outer cores are strongly coupled. He and his worldwide list of collaborators has been studying space geodetic measurements of strain accumulation globally and in Alaska, South America, and Central Asia. Immediately after the 17 Jan 94 Northridge earthquake in Los Angeles, Professor Bradford Hager and Principal Research Scientist Robert King resurveyed parts of the Southern California geodetic network to determine the extent of rupture on the hidden Northridge fault and to begin monitoring post-seismic motions. Hager, Dr. Peter Molnar, and Dr. Rob Reilinger have resurveyed and greatly expanded their network in the Tien Shan Mountains of Central Asia, determining for the first time the rate of convergence across the northern part of the mountains. Hager and graduate student Mark Simons used data from the Magellan Mission to show that the effective viscosity of the uppermost mantle is greater for Venus than for Earth, despite the high surface temperatures on Venus. In March of 1994, Professor Marcia McNutt and coinvestigators completed the largest and most ambitious seismic experiment ever attempted in an inland waterway. Using a state-of-the-art, 3-km-long multichannel seismic streamer, 2800 cu in airgun array, and 50 digital land seismometers, they imaged the structure of the crust and upper mantle beneath Lake Mead, a man-made lake in the Colorado River just east of Las Vegas. The purpose of the experiment is to understand why and how the North American continent is rifting apart. Professor Tom Jordan and graduate student Jim Gaherty have collected new structural information about the anisotropic structure of the earth's upper mantle and used it to constrain stochastic models of fine-scale heterogeneity in the lithosphere.

The addition of Professor F. Dale Morgan to the faculty of the Earth Resources Laboratory has broadened the scope of ERL's research in rock physics, electrical studies, and environmental geophysics. Morgan is developing new models of how surface chemistry affects the physical properties of rocks and has initiated environmental geophysics programs at the Aberjona Superfund Site and Otis Air Force Base, aimed at delineating buried contaminants. Professor Nafi Toksöz and graduate student Craig Schultz have studied enhanced backscattering of seismic waves from irregular interfaces, including ultrasonic backscattering experiments done in conjunction with Dr. Zhenya Zhu. Principal Research Scientist Arthur Cheng and graduate students Ningya Cheng have developed a three-dimensional model of seismic wave propagation in an anisotropic and heterogeneous formation using the finite difference technique. This algorithm has been been implemented on the 512-node nCUBE2 massively parallel computer at the ERL.

**Planetary Science**

Professor Timothy Dowling and his students have been simulating Jupiter's atmospheric response to the upcoming July 1994 collision of comet Shoemaker-Levy 9. They have also modeled the atmospheric dynamics of Neptune's Great Dark Spot and Saturn's Polar Hexagon. Principal Research Scientist Heidi Hammel has been selected to be team leader for Hubble Space Telescope's observations of Jupiter during the Shoemaker-Levy collision. She recently discovered a significant change in Neptune's brightness distribution, indicating that the planet's northern hemisphere has become active. Professor Richard Binzel and graduate student Shui Xu have utilized the 2.4m Hiltner telescope of the Michigan-Dartmouth-MIT Observatory to conduct remote sensing observations of asteroids in an effort to establish associations with known meteorite classes. This work, involving spectroscopic measurements at visible wavelengths, has established a firm link between the asteroid Vesta and basaltic achondrite meteorites. In addition, they have found the first evidence for a link between asteroids in the main belt and the most common class of meteorites, known as ordinary chondrites. Professor James Elliot, graduate student Catherine Olkin successfully observed a stellar occultation by Neptune's satellite Triton with NASA's Kuiper Airborne Observatory (KAO), yielding data to test theories of global change of Triton's atmosphere. They also used the KAO to observe a stellar occultation by the comet Chiron, revealing a feature only a few kilometers wide near Chiron's nucleus.

Professor Jack Wisdom is continuing his studies of the long term evolution of the solar system. With graduate student Jihad Touma he has found that the spin-axis tilt of Mars is wildly chaotic on timescales of 100 million years. They are presently reexamining the evolution of the Earth-Moon system, addressing whether the chaos in the planetary orbits affect the evolution of the lunar orbit and the obliquity history of the Earth. With graduate student Matthew Holman he has systematically studied the dynamical evolution of comets in the proposed Kuiper belt, outside the orbit of Neptune; their calculations add strong support for the hypothesis that short period comets originate in the Kuiper belt. Professor Gordon Pettengill is investigating the mechanism behind the peculiar, very high radar reflectivity seen over a few percent of the surface of Venus, primarily at high elevation. Bistatic radar observations involving the Magellan spacecraft were carried out last fall and again this spring in an attempt to shed further light on this process. Professor Charles Counselman is developing more precise methods of monitoring motions of the earth's crust continuously, in real time, by satellite.

THOMAS H. JORDAN
DEPARTMENTAL STATISTICS

Students
During the academic year 1993-94, there were 227 undergraduates majoring in mathematics, 155 in Course XVIII, Mathematics, and 72 in Course XVIII-C, Mathematics/Computer Science. Bachelor of Science degrees were awarded to 81 students, 58 in Course XVIII, including the double majors, and 23 in Course XVIII-C.

There were a total of 109 graduate students in mathematics, all in the Ph.D. program. This year 29 students received the doctoral degree and four received the master’s degree.

Faculty
There were 49 faculty members in the Mathematics Department. The following were on whole or partial leave:

- Professor Alexander Beilinson (spring term)
- Professor Daniel Freedman (year)
- Professor Harvey Greenspan (spring term)
- Professor Kenneth Hoffman (year)
- Professor Michael Hopkins (fall term)
- Professor George Lusztig (fall term)
- Professor Yuri Manin (year)
- Associate Professor Ehud Hrushovski (year)

There were five Visiting Professors in mathematics this year:

- Professor Carlos Kenig from the University of Chicago (spring term)
- Professor Anthony Knapp from State University of New York at Stony Brook (year)
- Professor Robert Kottwitz from the University of Chicago (spring term)
- Professor Nicolai Makarov from the California Institute of Technology (fall term)
- Professor Carlos Simpson, Director of Research at the Laboratory for Topology and Geometry, National Center for Scientific Research, Toulouse, France.

FACULTY CHANGES

Retirements and Resignations
Professor Bertram Kostant retired from MIT after a distinguished career as a teacher and representation theorist.

New Appointments
Dr. Fabian Waleffe has accepted an Assistant Professorship appointment; his specialty is computational fluids.

Promotions
Professor Ehud Hrushovski was promoted to Professor of Mathematics; his field is mathematical logic.

Honors, Prizes and Awards
Professor Daniel Freedman received the 1993 Dirac Medal and Prize (with Sergio Ferrara & Peter van Nieuwenhuizen) for his development of supergravity theory.

Professor Victor Guillemin was selected by the department faculty to the Norbert Wiener Professorship through 1998, following the tenure of Professor Michael Artin.

Professor Victor Guillemin shared the School of Science Teaching Prize for excellence in graduate student teaching.

Professor Victor Kac received the Wigner medal (with R. V. Moody) for his work on affine Lie algebras.

Assistant Professors Scott Axelrod and Alan Edelman were awarded Alfred P. Sloan Research Fellowships.
Graduate students Tom Braden, Brooke Shipley and Shinya Watanabe received Alfred P. Sloan Doctoral Dissertation Fellowships.

Seniors Justin Corvino and Andrew Przeworski were awarded the Jon A. Bucsela Prize in Mathematics in recognition of distinguished scholastic achievement. There were seven seniors in mathematics elected to the national honor society Phi Beta Kappa.

ADMINISTRATION
Professor Michael Artin replaces Professor Sy Friedman as Chairman of the Undergraduate Committee.

The remaining committee chairs remain the same:

- Professor Haynes Miller - Pure Mathematics Committee
- Professor Richard Stanley - Applied Mathematics Committee
- Professor David Vogan - Graduate Committee
- Professor James Munkres - Committee of Advisors

EDUCATIONAL
Among the educational initiatives of the department, here are the ones that involve the undergraduate core.

Some fine tuning has strengthened the curriculum. The department has established three two-term calculus sequences: 18.01 & 18.02 Calculus, 18.011 & 18.021 Calculus with Applications, and 18.014 & 18.024 Calculus with Theory. As the students arrive with diverse backgrounds, all but one of the resulting six one-semester courses is offered in the fall term, with satisfying enrollments. Freshman seminar offerings are doing well, with an average of three offered each term. The course in algebraic topology, 18.904 Seminar in Topology, is very successful as an undergraduate seminar. The honors version of differential equations, 18.034 Differential Equations, continues to be successful as well.

Efforts continue toward the improvement of the quality of teaching. The Dean of Science has offered a program to videotape faculty and instructors. Professors Sy Friedman and Arthur Mattuck lead in the critiquing of the videotapes. Peggy Enders from the office of the Dean for Undergraduate Education hosts a series of meetings to orient and obtain feedback from recitation instructors, and to increase communication among faculty lecturing the core science courses at MIT.

One of the important topics of discussion at these meetings concerns the mathematics diagnostic, a precalculus exam given to entering freshmen. The results suggest that our entering freshmen do have serious deficiencies in precalculus and the department now administers a precalculus exam as part of the MIT requirements.

DAVID J. BENNEY
During the past year, the Physics Department maintained its position as a leader across the frontiers of physics research. A flavor of these activities is given in the brief accounts later in this report and in the more detailed reports from laboratories with significant physics participation. On the academic side, several new and continuing thrusts speak to the department's commitment to its educational program.

The members of the Physics Department continue to provide leadership for major MIT interdepartmental laboratories. Currently, the Directors of the Laboratory for Nuclear Science (LNS), Bates Linear Accelerator Center, Center for Space Research, Center for Materials Science and Engineering (CMSE) and Harrison Spectroscopy Laboratory are members of the Physics Department, as well as the Associate Directors of the Research Laboratory of Electronics (RLE) and the Plasma Fusion Center (PFC). In addition, Professors Robert J. Birgeneau and J. David Litster serve as Dean of the School of Science and Vice President and Dean for Research, respectively. Professor Robert L. Jaffe is Chair of the Faculty for a two-year period. In 1993-94 the total number of faculty was 82. Jacqueline Hewitt was promoted to Associate Professor without tenure, Simon Mochrie and Barton Zwiebach were promoted to Associate Professor with Tenure and Edward Farhi was promoted to Professor. Three new Assistant Professors joined our faculty: Tomas Arias, Wolfgang Ketterle and Charles Steidel. Faculty on leaves or sabbaticals during this year included: Tomas Arias, Michael Baranger, George Benedek, Edmund Bertschinger, George Clark, Earl Lomon, John Tonry. Professor Vera Kistiakowsky retires from the Physics faculty on July 1, 1994.

A number of faculty received awards during the past year. Paraskevas Sphicas was selected the Cecil and Ida Green Career Development Professor. Professor Bruno Coppi has received the Special Prize by the Presidency of the Government of Italy for Culture (scientific research) presented at a ceremony in Rome and the European Italgas Prize for Research and Innovation. Professor Coppi has also been asked to serve as a Senior Fellow of the Italian Academy for Advanced Studies in America. Professor Ali Javan was selected by the World Cultural Council as the recipient of its 1993 Albert Einstein World Award of Science. Institute Professor Mildred Dresselhaus was the 1993 Zachariasen lecturer at the University of Chicago, was granted an honorary degree from Johannes Kepler University in Linz, Austria and was elected a foreign associate of the Engineering Academy of Japan. Professor Robert Jaffe was elected an American Association for the Advancement of Science Fellow. A day-long symposium was held honoring Professor George Benedek on his 65th birthday. Professor Thomas Greytak was awarded the Physics Department Buechner Prize for excellence in Teaching and the School of Science Teaching Prize in Undergraduate Education. Professor Raymond Ashoori was awarded a Fellowship in Science and Engineering from the David and Lucile Packard Foundation and an Alfred P. Sloan Foundation Award. Professor Charles Steidel also received an Alfred P. Sloan Foundation Award.

EDUCATIONAL ACHIEVEMENTS AND INNOVATIONS

The Department continues to maintain a steady number of graduate and undergraduate students and a slightly increased number of credit units per faculty member. This year the number of undergraduate majors was 221 and the number of graduate students was 297. The number of degrees awarded totaled 70 S.B., 9 S.M., 51 Ph.D.

A number of changes took place in the educational program this year or are in the planning stages for implementation over the next several years. Fall, 1992, was the first offering of 8.01L, a course that covers the same material as 8.01 but extends the time by three weeks through the January Independent Activities Period (IAP). The intent of 8.01L is to give students a chance to assimilate more fully the calculus in 18.01 before it is introduced in 8.01L and to relieve some of the pressure of the first semester of the freshman year. Enrollment rose slightly in 8.01L this year (the second year) and favorable student comments continue.
8.03X, a "hands-on" approach to physics instruction through take home experiments, introduced in Spring, 1992 by Professor Greytak was incorporated into the "on-semester" 8.03 taught by Professor Hewitt in Fall, 1993.

The subgroup of the Education Committee studying revisions to the Physics major Curriculum completed its work. Requirements will now include: a subject in the sophomore year that covers special relativity and intermediate mechanics; a course in the applications of quantum physics; an IAP requirement of either an intensive project laboratory or a course in advanced classical mechanics. The intensive Project Lab will be offered during IAP in 1995. The new curriculum applies to the 1994 entering class.

Intensive preparation for the revised 8.01 took place this year. Course guides were completed during the Spring, 1994, the very real scheduling problems of finding space and time for 40 small classes was resolved through the efforts of both the registrar's office and the Undergraduate Physics office, and 21 faculty are committed to the first year's efforts.

The department has been fortunate to have Institutional support for several educational projects. Funding for Course Guide development for 8.01 was provided by the "Class of '51 Excellence in Education Fund", and funding for computer equipment and interfaces for the IAP Physics Project laboratory came from the Ferry Fund. The Dean of Undergraduate Affairs has supported departmental efforts to improve teaching by partial support of the fee for individual videotape consultations. These consultations have been well used and well received by the faculty.

The graduate curriculum is being revised to consolidate course offerings in the six major research areas of the department. These revisions are still underway, and should be fully implemented in the 95-96 academic year.

CURRENT RESEARCH

The range of high quality forefront basic research activities pursued by the MIT physics faculty is unmatched at any other physics department. This is reflected in the large number of Institute laboratories and centers which support substantial research programs of the Physics faculty. The reports from the Laboratory for Nuclear Science, including the Bates Linear Accelerator Center and the Center for Theoretical Physics, the Center for Materials Science and Engineering, the Research Laboratory of Electronics, the Center for Space Research, the Plasma Fusion Center, the Harrison Spectroscopy Laboratory, and the Haystack Observatory should be consulted for a more complete description of some of these research programs. We can provide only a brief overview in the space made available here.

Astrophysics

Research in Astrophysics deals with our attempts to understand the universe on the largest scales. Phenomena ranging from solar oscillations, to accreting black holes in the Galaxy, to quasars at cosmological distances are studied. Observational programs involve the collection, analysis, and interpretation of data from a wide variety of ground-based and space-based observatories. Theoretical research is carried out on a wide range of topics that are both complementary to, and independent of, the observational program.

X-ray astronomy continues to be a major area of research. Observational programs utilize the Japanese satellite ASCA, which features a CCD imaging X-ray detector developed at MIT, as well as the German satellite ROSAT. Binary systems with accreting compact objects (e.g., neutron stars), hot plasma in supernova remnants, clusters of galaxies containing dark matter, distant quasars, and the cosmic X-ray background are being actively studied.

Searches for new gravitational lenses, including "Einstein rings" are a major activity of the radio astronomy group. Gravitational lenses provide a probe of the lensed object as well as of the dark matter within the lensing galaxy, and can lead to a determination of the Hubble constant.
MIT optical astronomers utilize the Michigan-Dartmouth-MIT observatory in Arizona, as well as other telescope facilities around the world. Several programs aimed at identifying extragalactic objects found in the radio and X-ray bands are underway. Large scale flows in the universe are being studied with a newly developed fluctuation-distance-indicator technique which yields relative distances accurate to ~5%. Studies of metal-line absorption systems in quasars provide a better understanding of galaxy formation to "lookback" times that are a substantial fraction of the age of the universe.

Development work continues on LIGO, a collaborative project of MIT and Caltech to construct a laser interferometer gravitational wave observatory with two 4-km baseline facilities capable of detecting gravity waves from astrophysical sources. LIGO management has been changed substantially.

The MIT Plasma Science Experiment on board the Voyager Interstellar Mission continues to measure the properties of the solar wind in the distant heliosphere. A new plasma experiment for WIND was completed and delivered to NASA last year for a scheduled launch this fall.

Theoretical research in helioseismology is leading to a better understanding of the internal structure of the Sun, e.g., its internal differential rotation. Theoretical studies are continuing of the formation and evolution of binary systems containing collapsed stars, including "recycled pulsars" and the newly discovered class of "supersoft" X-ray sources. Theoretical studies of the large scale structure of the universe and departures from the smooth Hubble velocity flow are being actively pursued, including the use of large cosmological N-body simulations. The cold dark matter model for galaxy formation, as well as other models, are being extensively investigated. Activities in theoretical astrophysics have been substantially broadened and bolstered by the appointment of two junior faculty members - Pawan Kumar (two years ago) and Fred Rasio (this year).

**Nuclear and Particle Experiment**

Nuclear and particle physicists are working to uncover the fundamental particles and forces and to understand how these yield the properties of the strongly interacting matter which makes up nearly the entire mass of the visible universe. These studies are intimately related with cosmological studies of the early universe.

In Intermediate Energy Nuclear Physics, electron scattering research programs included measurements of the neutron charge and magnetization distribution, studies of quasi elastic electron-proton scattering in nuclei at high momentum transfer and high missing energies, study of the phenomenon known as "color-transparency" and use of parity non-conservation as a novel probe of proton structure. Complementary studies of pion-induced reactions are being carried out at Los Alamos and at PSI (Switzerland).

At Bates, work continued on commissioning the South Hall Ring and on improving the reliability of the accelerator. Important future initiatives are: the BLAST detector (Bates Large Acceptance Spectrometer Toroid), which is now fully designed; the HERMES experiment under construction at DESY; and the completion of the high resolution spectrometer system for CEBAF.

In Heavy Ion Physics, with the installation of Au beams at the Brookhaven AGS, the systematic study of nucleus-nucleus collisions was extended into the region of higher matter density. A new initiative was started at CERN's heavy ion facility by one of the junior faculty members, Bolek Wyslouch, to search for evidence of the creation of different states of the vacuum. Following the approval from BNL, the design and construction of the PHOBOS detector began under MIT leadership. It will exploit the opportunities offered by the new collider, RHIC, at BNL. Also, an involvement has begun in the search for strange matter produced in heavy ion collisions.

In Particle Physics, the current research included: i) the probing of the Standard Model and detailed studies of the Z' particle using the L3 detector at LEP; ii) studies of the highest energy pp collisions, using the CDF at Fermilab, and obtaining the first direct evidence for the existence of the elusive top quark; iii) first look at the left-right cross-section asymmetry for Z' production using polarized electrons
and the SLD detector at SLAC; and iv) high statistics studies of charmed particles produced at the Beijing electron-positron collider. Significant effort was spent in exploring the research opportunities at the future accelerator LHC planned at CERN. Involvement in the construction of the world’s largest underground cosmic ray laboratory at Gran Sasso, the development of novel nuclear and particle detectors, and construction of a novel axion search detector continued.

**Nuclear and Particle Theory**

Research at the Center for Theoretical Physics seeks to extend and unify our understanding of the fundamental constituents of matter and the theory that governs them. In addition, it uses our present knowledge of this theory to advance our understanding of a variety of subjects, including the structure and interactions of hadrons and nuclei, new forms of matter which may be created experimentally or observed astrophysically, and the behavior of the early universe.

String theory aims to unite the strong, electroweak, and gravitational interactions and to explain the observed hierarchy of particles and interactions. An important contribution at MIT has been the development of a general field theory of closed strings. It has recently been shown that this theory is independent of the background field that is used in its construction. Finite temperature effects have been incorporated into string theory, leading the way to the study of cosmology and radiation from black holes.

Topological terms in field theories, which were introduced by this group several years ago, are now widely studied in problems ranging from gravity to high temperature superconductivity. Recently, these terms were shown to play an important role in QCD at high temperature and used to understand the response function in the quark-gluon plasma.

A striking feature of general relativity is the existence of particle trajectories that travel backwards in time. Although such trajectories exist as formal solutions, the systems allowing such solutions have been shown, in the cases which have been studied, to be unphysical or impossible to create from physically acceptable initial conditions.

The role of underlying quark and gluon degrees of freedom in hadrons, hadronic interactions, and nuclear structure is of fundamental interest. New formulations of Yang-Mills gauge theory have been developed in terms of gauge-invariant variables, and the possibility of observing new multiquark resonances in hadron scattering has been studied.

A major recent thrust has been in the area of lattice gauge theory, which provides a unique tool to solve, rather than model, QCD. Recent lattice solutions have provided strong evidence that the structure of nucleons, pions and other light hadrons is dominated by topological excitations of the gluon field. To exploit the fundamental opportunities in this field, a development project to build a Teraflops computer at MIT is underway in partnership with the Laboratory for Computer Science, Thinking Machines Corporation, Lincoln Laboratory, and a national collaboration of physicists.

MIT has played a pioneering role in exploiting high energy scattering to determine the quark and gluon structure of nucleons and nuclei. Significant new developments have been the determination of the behavior of structure functions in the new regime to be studied at CEBAF, the discovery of new ways to measure spin dependent structure functions, and the first successful theory of the fragmentation function for pions.

CTP theorists have developed extensions of the Standard Model, including extended Technicolor and supersymmetric models, which agree with known data and make testable predictions. Developments in heavy quark physics have been used to find new ways to study CP violation in B meson mixing, and to determine weak matrix elements from B decays.

Electroweak interactions are a continuing focus of research. The unique opportunities provided by the new ring at the Bates accelerator have motivated studies of reaction mechanisms, of new ways to use
nuclei to test fundamental symmetries, and of spin and polarization observables. The use of neutral current probes to study the strange quark content of the nucleon has been studied. Anti-neutrino and heavy-flavor neutrino production from the sun have been studied to obtain new information on the solar neutrino anomaly and neutrino mixing.

Efforts have continued to understand the nature of periodic solutions in multi-dimensional classical systems and their implications for quantum chaos, and the first periodic solutions for many-fermion systems have been obtained numerically. Nuclear reaction theory has been used to explain the parity violation observed experimentally in low energy neutron scattering and the compound nucleus enhancements in photon production by proton-nucleus scattering.

Atomic, Condensed Matter, and Plasma Physics

During the past year research in the Division of Atomic, Plasma and Condensed Matter Physics has advanced in a number of areas. A new technique was developed for comparing the masses of two ions of widely differing atomic weight. New values were obtained for 10 atomic masses important for metrology or for the determination of fundamental constants, with improvements of one to three orders of magnitude over previous values. Two methods are currently being used to cool atoms to ultra-low temperatures: evaporative cooling (developed at MIT) and laser cooling. These techniques have now been combined; a gas of atoms cooled by interaction with a laser has been further cooled, and had its density increased, by evaporation. By this means fundamental limitations, associated with each technique used separately, can be circumvented.

Free electron lasers offer great potential as powerful, tunable sources of coherent radiation. They are most often used in the infrared region of the spectrum, but MIT has developed a "micro wiggler" structure which extends the operation into the visible and near ultraviolet. MIT’s state of the art tokamak, Alcator C-MOD, is now operational and being used to study collective phenomena and transport mechanisms in high temperature, reactor relevant plasmas. It is the only new magnetic confinement facility built in the US in the last decade, and is expected be our premier machine for the next decade.

It has long been known that proteins can exist in several different stable configurations depending on their environment (temperature, pH, etc.). Similar stable structures have now been demonstrated in the gel phases of synthetic polymers. The polymers are, in fact, random sequences of copolymers and thus differ from the proteins in which the chemical sequence is fixed. None the less, the phases of the gels are characterized by discrete degrees of swelling. These studies impact the areas of protein folding, molecular recognition, and catalysis. A new universality class for critical behavior in two dimensions has been found experimentally in the reconstructions of a silicon surface. The transition, chiral melting, is a realization of an as-yet unsolved theoretical model. Theorists have predicted that the sticking probability for an extremely low energy atom impinging on a surface should go to zero as the square root of the atom’s energy. This universal behavior has been observed for the first time using spin-polarized atomic hydrogen at sub-millikelvin temperatures striking a puddle of superfluid helium.

Current advances in the technology of mesoscopic systems have allowed careful quantitative measurements of the edge states of quantum dots. In response, a theory has been developed which predicts anomalous ring-like electron distributions at the periphery of circular quantum dots. This may be the explanation for unexpected features of the experimental results found at MIT and elsewhere. The math and computational techniques associated with electronic band structure have proven to be ideally suited to the analysis of photonic materials. As a result, the Department has developed a strong theoretical effort in the study and design of these fascinating materials. Finally, work on quantum chaos has evolved to the point where a quantitative statistical theory is being developed. It appears that there may be a non-trivial and deep connection between the mathematics of quantum chaos and that of other important physical systems such as strongly correlated spin systems and quantum gravity.

ERNEST J. MONIZ
The Center for Cancer Research was established in 1973 to study fundamental biological processes related to cancer. The goals of the Center's research can be generally stated as developing an understanding of (1) the genetic and molecular basis of cancer, (2) how alterations in cellular processes affect cell growth and behavior, and (3) how the immune system develops and recognizes antigens. These goals are related to the Center's major research programs in oncogenes and mammalian genetics, molecular, cellular and developmental biology, and immunology. Approximately 200 people work in the Center, distributed among the research laboratories of 12 faculty.

Financial support for research in the Center comes from many sources. The core of this support which provides much of the funds for administration, partial faculty salary support, and central research facilities (i.e. glass washing facility, specialized laboratories and partial support for new faculty) is a Center Core grant from the National Cancer Institute. This grant was renewed in 1990 and its current term extends to April 30, 1995. An application for renewal for a further five years has been submitted. In addition to the core grant, the Center's faculty have a total of 44 fully funded projects (plus over half a million dollars of competitive support in fellowships for postgraduate studies). This support comes largely from the National Institutes of Health and the Howard Hughes Medical Institute and from a variety of foundations supporting research in particular disease areas (American Cancer Society, Hereditary Disease Foundation, Muscular Dystrophy Association, National Neurofibromatosis Foundation, etc.). This latter type of support is particularly valuable for starting projects which later mature into federally funded grants. The Center's success in attracting grant support is a reflection of the excellence of the research and educational activities of its faculty members.

Several groups in the Center study the identity of oncogenes. This work includes the recent identification of the Wilm's tumor oncogene as well as basic molecular studies on other oncogenes and tumor suppressor genes that regulate gene expression controlling the cell cycle and tumor growth. Another focus is on the biochemical mechanisms controlling RNA transcription and splicing, including studies of genes of the AIDS virus, HIV.

The immunologists in the Center study the development of cytotoxic and helper T lymphocytes, their antigen-specific receptors, and the molecular mechanisms of antigen presentation. Since the immune response to tumors is poorly understood, these basic studies are crucial to a more profound analysis of tumor rejection. Immune cells can destroy cancer cells and it may be possible to stimulate this process.

The cell biologists study cell surface proteins involved in cellular adhesion and migration, as well as cytoskeletal proteins involved in cell motility and shape. Alterations in cell adhesion proteins contribute to the malignant phenotype of tumor cells. These proteins as well as cytoskeletal proteins are important targets for antitumor drugs, and deeper understanding of their structure and function should contribute to better therapeutic agents.

Since the cellular processes of development and cancer have much in common, useful insights into the behavior of tumor cells can be obtained from studies of normal embryos; several projects in the Center focus on developmental processes. Recent advances in the generation of transgenic mice and mice with mutations in targeted genes are being exploited to investigate the roles of a variety of proteins important in tumorigenesis, including oncogene proteins, tumor suppressor genes, cell adhesion receptors, T-cell receptors and protein kinases.

Major research advances in the past year include:

— the discovery by the Housman and Jacks groups that the susceptibility of tumor cells to chemotherapy or radiation can be predicted by their complement of tumor suppressor genes and oncogenes.

— the generation by the Tonegawa laboratory of strains of mutant mice defective in various aspects of learning and memory.
In addition to its strengths in basic research, the CCR performs an important role in training future researchers in biomedical science, including undergraduate and graduate students, postdoctoral and clinical fellows. The faculty of the Center fulfill critical roles in the educational programs of the Department of Biology. Our colleague, Dr. Phillip Sharp, has served as Head of the Department for the past three years. Dr. Frank Solomon serves as Chairman of the Department's Graduate Program. Extensive collaborations exist with medical schools, hospitals and the biotechnology/pharmaceutical industries. Thus, the research in the CCR has a major impact both on the fundamental understanding of cancer and on translation to and from the clinical arena.

A major strength of the Center remains its attractiveness as an environment for the training of young scientists. The Center has 58 graduate and undergraduate students and 70 postdoctoral fellows/associates. The Center also benefited from a number of international faculty-rank visitors during the past year.

Major honors received by faculty of the Center during this past year were:

Professor David Housman was elected to the National Academy of Sciences.

Professor Richard Hynes was elected to the American Academy of Arts and Sciences.

Professor Tyler Jacks has been named as an Assistant Investigator of the Howard Hughes Medical Institute.

Professor Jun Liu will hold the Pfizer-Laubach Career Development Professorship for three years beginning July 1, 1994. He will also receive a Searle Scholar Award effective July 1, 1994.

Professor Phillip Sharp, together with Dr. Richard Roberts of New England Biolabs, received the 1993 Nobel Prize for Medicine and Physiology for his discovery of RNA splicing, a key discovery in the understanding of gene structure and function.

Professor Frank Solomon received the 1993-1994 School of Science Graduate Teaching Award.

Professor Susumu Tonegawa has been selected to be the first Amgen Professor of Biology and has been named as the first Director of the new Center for Learning and Memory at MIT.
THE CENTER FOR SPACE RESEARCH (CSR) conducts an active program of research in astronomy, space science, and related technology, with emphasis on experimental and theoretical investigations in support of various National Aeronautical and Space Administration (NASA) flight missions. Specific areas of research include gravity-wave, X-ray, optical, radio, and radar astronomy; theoretical and experimental space plasma physics; planetary surfaces and atmospheres; and the space life sciences. CSR is heavily involved in the following ongoing or upcoming joint projects: Voyager, the Magellan Venus Radar Mapper mission, the Cosmic Background Explorer (COBE), Mars Observer, the Japanese-US ASCA satellite, the Advanced X-ray Astrophysics Facility (AXAF), the X-ray Timing Explorer (XTE), the Space Transportation System (Shuttle) Spacelab series, and an investigation of Earth's plasma environment as part of the International Solar Terrestrial Physics Program (ISTP). The High-Energy-Transient Experiment (HETE), is a small, inexpensive satellite under CSR's direct control. CSR also supports investigators in the Space Engineering Research Center and administers a program of theoretical astrophysics and of optical observations carried out at the Michigan-Dartmouth-MIT (MDM) Observatory. Much of the research carried out in CSR is reported by the following departments: Physics, Earth Atmospheric & Planetary Sciences, and Aeronautics & Astronautics.

ASTRO-D (ASCA) Mission and Analysis of Data from Satellite X-ray Observatories. Following the launch of the ASCA satellite last year (a joint undertaking of CSR, NASA and ISAS in Japan), CSR has been participating in the operations planning, calibration, and data analysis. The CSR provided CCD X-ray detectors (developed in collaboration with Lincoln Laboratory) continue to operate well and are returning spectrally resolved images of unprecedented quality. MIT personnel are participating in numerous astronomical projects, including studies of the diffuse X-ray background, supernova remnants, clusters of galaxies and distant quasars. The MIT X-ray group also continues its observational program using the German ROSAT X-ray telescope, as well as archival studies of galactic and extragalactic objects from previous US, Japanese and European X-ray missions.

Development of X-ray Astronomy Experiments. The XTE instrumentation is being reworked following initial delivery to NASA's Goddard Space Flight Center. XTE will study the time variability of celestial X-ray sources at time scales ranging from tens of microseconds to years over energies of 2-100 keV. HETE, which will search for bright transient emissions from astronomical objects over a very broad energy interval from the UV to gamma rays, is on track for launch in April 1995. AXAF is a major NASA mission of the "great observatory" series, scheduled for launch in 1998. The two instruments being designed at MIT, the High-Energy Transmission Grating Spectrometer and the AXAF Charge-Coupled Device (CCD) Imaging Spectrometer have passed the major milestone of Preliminary Design Review.

Michigan-Dartmouth-MIT Observatory. MDM is located on Kitt Peak near Tucson, Arizona, where two telescopes, 1.3 m and 2.4 m in diameter, are operated jointly by the University of Michigan, Dartmouth College and MIT. A new, very large format CCD camera was commissioned by MIT for the observatory. Active projects at MDM include studies of the cosmic distance scale, gravitational lenses, detection of galaxies at very high redshifts, mapping the structure of the Milky Way and the classification of asteroids.

Interplanetary, Magnetospheric and Ionospheric Plasmas. Study of the properties of solar wind plasma at large distances from the Sun continues with Voyager 2, which is on its way out of the solar system. The group is preparing for the delayed launch of the WIND spacecraft, which will carry a plasma cup built at CSR. WIND is part of an international program to study the solar wind and its interaction with the earth's magnetosphere. The Center of Excellence in Theoretical Geo/Cosmo Plasma Physics continues to compare the apparently excellent agreement between theoretical models of ionospheric plasma phenomena and the recent data obtained from the Freja, Viking satellites, and TOPAZ rocket series.

Planetary Missions. The Magellan mission radar experiment was turned off following its successful mapping of the entire surface of Venus at a resolution approaching 100 m. Magellan's orbit was circularized using a novel aerobraking technique in order to complete gravity mapping. The failure of Mars Observer during this past year was a major disappointment. CSR is also participating as a node in the planetary data systems network.

Gravitational Wave Research & Cosmology. The Laser-Interferometer Gravitational Wave Observatory (LIGO), a joint project of Caltech and MIT to develop and construct two 4km baseline gravitational wave interferometers in the continental United States to operate in concert with interferometers in Europe, continues research and development. The project, which is moving into the development phase, is now being reorganized under a new Caltech principal investigator. Current work on the MIT 5m interferometer centers on understanding and controlling the sources of phase noise and investigating active seismic isolation control systems.
Aerospace Physiology and Man-Machine Systems. The Space Life Sciences spacetlab mission, SLS-2, had a successful flight this past fall. The astronauts conducted several vestibular research experiments of the Man-Vehicle Lab, with Professor Larry Young as a mission specialist at mission control. The experiments included an novel automated expert system for experiment control.

Theoretical Astrophysics. Several faculty associated with the Center for Space Research carry out research programs in theoretical astrophysics. Topics include cosmology and the inflationary universe scenario, the large scale structure of the universe, galaxy formation, studies of solar oscillations and the structure of the solar interior, stellar accretion disks, binary star evolution, physics of active galactic nuclei, and other topics. For details see the report of the Astrophysics Division of the Physics Department.

Space Engineering and Technology. CSR supports spaceflight activities of the Space Engineering Research Center and of other faculty in Aeronautics and Astronautics. This year saw the successful refight of the shuttle-based MODE dynamics experiment.

CLAUDE R. CANIZARES
For the past twenty-five years, the Experimental Study Group has provided a unique educational alternative to the regular curriculum for first year students at MIT. This alternative is based on the concept of self-motivated learning through small classes and tutorials. ESG has continued over the years to attract a great deal of interest from incoming students, primarily because of its flexible and interactive structure. ESG has adapted its offerings to be in step with the ongoing changes in the regular MIT curriculum, including greater emphasis on biology and the expanded use of computers as teaching aids.

STUDENT STATISTICS

The demand for ESG this year (69 student applicants for 50 places) led us to institute a lottery system for the first time and to increase the number of students in our program to 54. In order to accommodate the additional students, we increased the average size of our study groups. However, we found that increasing our enrollment beyond 50 students created difficulties in successfully addressing diverse student needs. We will therefore maintain our enrollment in future years at 50 or fewer students.

The total enrollment for fall term was 89 and for the spring term was 73, broken down as follows:

<table>
<thead>
<tr>
<th></th>
<th>Fall 1993</th>
<th>Spring 1994</th>
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<tbody>
<tr>
<td>Freshmen</td>
<td>51</td>
<td>34</td>
</tr>
<tr>
<td>Sophomore transfers</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>ESG upperclassmen</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Non-ESG upperclassmen</td>
<td>19</td>
<td>29</td>
</tr>
<tr>
<td>(in seminars)</td>
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Forty-one percent of ESG's freshman class for the year were female, 4 percent were minorities, and 20 percent were international students, from countries including Sri Lanka, Switzerland, Argentina, and Sweden.

The 51 sophomores currently registered at MIT who had been in ESG as freshmen earned a cumulative median grade point of 4.5 this spring, a figure which is higher than the corresponding statistic for the entire MIT sophomore class. Approximately 41 percent of our sophomores are majoring in the School of Engineering, and 43 percent in the School of Science.

ADMINISTRATION

In addition to their teaching duties, Professor Vernon Ingram (Director of ESG) and Holly Sweet (Associate Director) administered and monitored program offerings and activities. They met several times during the year with the ESG Advisory Committee, currently composed of representatives from the School of Science.
(Dean Robert Birgeneau), the Department of Mathematics (Professor Alar Toomre), the Department of Physics (Department Head Ernest Moniz), the Department of Chemistry (Professor Alan Davison), the School of Humanities and Social Sciences (Dean Philip Khoury), and the School of Engineering (Professor Jack Kerrebrock).

STAFF AND FACULTY

The physics staff included Professors Emeriti Robert Hulsizer and Robert Halfman, Dr. Peter Dourmashkin, Craig Watkins, and David Custer '82. The mathematics staff was headed by Craig Watkins and graduate students Daniel Klain (fall term) and David Metzler (spring term). The chemistry offerings at ESG were supervised by Todd Anderson, a graduate student in the Department of Chemistry. Professor Ingram from the Department of Biology was responsible for the teaching of introductory biology in ESG.

The chemistry, mathematics, physics, and biology staff were assisted by 22 undergraduate and 9 graduate tutors. The undergraduate tutors (most of whom had been in ESG as freshmen) maintained a 4.6 median grade point average. We consider our undergraduate tutors to be one of ESG's strongest assets and indispensable to the successful operation of our program.

ESG also offered several HASS-D and HASS classes to its students. Eric Fernald, a graduate student in the Department of Political Science, taught political science and political philosophy, and Mr. Custer taught both expository and creative writing.

Undergraduate seminars sponsored through ESG included SEM051 Sex Roles and Relationships, SP293 Robotics, and 6A19 Introduction to Digital Electronics. These seminars attracted a combination of ESG and non-ESG students and proved to be very successful at acquainting regular curriculum students with our interactive mode of education.

ACADEMIC INITIATIVES

Given the need for training and supervision of undergraduate tutors throughout the term, the ESG staff introduced a new seminar on teaching (mandatory for new undergraduate tutors) which combined close supervision of actual teaching with theory about education. Four staff members and 13 students took part in this seminar. Because it was successful and cost effective (since tutors received academic credit rather than pay for hours spent outside of contact time with students), it will be repeated in the coming year.

Student satisfaction with the increased use of study groups was monitored through individual interviews with Ms. Sweet held during the spring term. Overall, students seemed quite happy with both the quality of instruction and the dynamics of the study groups. We intend to continue their use, being careful to insure good fit between students and instructors as well as capping group sizes at three to four students. However, we will also continue the use of
one-to-one tutorials where student needs necessitate individual instruction.

Mr. Anderson taught two recitation sections of 5.60 Thermodynamics and Kinetics for the first time during the spring term. He will be working with the Department of Chemistry to consider developing and teaching a two term sequence for 5.11 Principles of Chemical Science and 5.60.

This was the first year in which biology was a required subject at MIT. The School of Science has given ESG a three year grant to cover increased teaching costs as well as curriculum development. We used this opportunity to update our biology teaching, including using Mac-based BioQuest software to simulate experiments in genetics, evolution, and neurobiology. A new module will be available next fall. We also hired additional tutors to cope with the doubling of enrollment in biology and trained them through our teaching seminar and group supervision with Professor Ingram. We have begun to completely reorganize the ESG biology offering for next year, using a case study approach and a computer based workbook while maintaining the curriculum content. We are also developing molecular biology experiments which will become part of next year’s biology teaching at ESG.

ESG’s small size and interactive format have allowed ESG staff to begin to develop a detailed approach to matching academically talented freshmen with appropriate faculty members in their future fields of study.

ESG continues to provide a home for students and staff at MIT who are interested in a more individualized and experimental approach to education. We applaud the efforts of all of our community members who have contributed in their own ways in maintaining ESG as a valuable Institute resource for curricular and social innovation.

VERNON M. INGRAM
HOLLY B. SWEET
The George Russell Harrison Spectroscopy Laboratory is engaged in research in the field of modern optics and spectroscopy for the purpose of furthering fundamental knowledge of atoms and molecules and pursuing advanced engineering and biomedical applications. Techniques include the use of lasers and modern optics. The Laboratory is directed by Professor Michael S. Feld of the Department of Physics. Professor Jeffrey I. Steinfeld of the Department of Chemistry and Dr. Ramachandra R. Dasari, Principal Research Scientist in the Laboratory, are Assistant Directors. Professors Michael S. Feld, Robert W. Field, Keith A. Nelson, Stephen J. Lippard, Jeffrey I. Steinfeld, Toyoichi Tanaka, Mark S. Wrighton, and Dr. Ramachandra R. Dasari are core investigators of the Laboratory.

An Interdepartmental Laboratory, the Spectroscopy Laboratory encourages participation and collaboration among researchers in various disciplines of science and engineering. Research contributors this past year were from several MIT departments including Chemistry, Physics, Biology, Electrical Engineering and Computer Science, Mechanical Engineering, and Materials Science and Engineering. There were also numerous collaborations with outside academic institutions, many of an interdisciplinary nature, as well as with government, industrial and medical organizations.

This past year was one of continued growth. A new Picosecond-Femtosecond Laboratory has been established to pursue photon migration and ultraviolet resonance Raman spectroscopy research. It contains a mode-locked Ti:sapphire laser and a super doubler/tripler/quadrupler to generate wavelengths between 210 and 500 nm. This laboratory is also equipped with a 1 m grating spectrograph, a UV-sensitive CCD array detector and a UV microscope. A super doubler/tripler to generate different dye laser wavelengths was added to the existing Ultrashort Pulse Laboratory. A compact Raman spectograph incorporating a diode laser and an optical fiber probe for excitation and collection were developed for the Laser Biophysics Laboratory. A long-pulse seeded Nd:YAG laser, along with high frequency modulators, has been purchased for the Pulsed UV-Visible Kinetics Laboratory in order to pursue new investigations in 2D-spectroscopy of small molecules.

Dr. Lev Perelman joined the Sponsored Research Staff of the Laboratory, and Dr. Ramasamy Manoharan was promoted to Research Scientist, and Ronald Tanguay was appointed as Research Technician.

The MIT Laser Biomedical Research Center (LBRC) is now in its ninth year of operation as a Biotechnology Resource Center of the National Institutes of Health. Biomedical applications of lasers and laser spectroscopy promise to change the face of medicine as it is currently practiced. The LBRC's charter is to develop the scientific understanding required for advanced clinical applications of lasers. LBRC activities can be grouped into three categories: Optical histochemistry; molecular mechanisms of tissue ablation; and biophysics and biochemistry of biopolymers. In addition to core research, collaborative and outside research projects are conducted at the Center. Resources of the Center are provided free of charge on a time-shared basis to medical researchers who wish to pursue research in this important new field.

The National Science Foundation continues to support the MIT Laser Research Facility, which conducts core research programs in the physical sciences of thirteen MIT Chemistry and Physics Department faculty members. The programs of the LRF include novel techniques for ultrasensitive spectroscopy, laser interactions with fundamental systems, photochemistry of engineered materials and photoinorganic and biochemical dynamics.

Information about the equipment and facilities of the LRF and the LBRC can be found in the Researcher's Guide, published by the Laboratory.

RESEARCH HIGHLIGHTS
Professor Steinfeld, in collaboration with Dr. Stephen Coy, a long-time associate of the Harrison Laboratory, and Dr. Bernd Abel, Wissenschaftliche Mitarbeiter at the University of Gottingen (Germany), has been using a Raman-shifted Ti:sapphire laser system in the Harrison Spectroscopy Laboratory to carry out infrared double-resonance spectroscopic measurements on overtone levels of methane. State-to-state rotational energy transfer rates have been obtained in ground and excited vibrational levels, and the probability of molecular reorientation inferred from the polarization dependence of the relaxation times. This information on energy levels, line intensities, linewidths, and collisional relaxation in these levels is needed for interpretation of spectroscopic remote-sensing measurements of objects in the Solar System such as Jupiter, Saturn, and Titan, as well as for monitoring of "greenhouse gases" in the Earth's own atmosphere.

Professors Field and Richard Redington of the Department of Chemistry, Texas Tech, continued work on the construction and testing of a cavity ring-down system for the study of ultra-weak UV/VIS absorption spectra of jet cooled samples. Pulsed laser light is introduced into, and leaked out of, the optical ring-down cavity by passage through the virtually opaque coatings of the highly reflective end-mirrors. The mirrors proved inadequate for the generation of ultra-long optical pathlengths and must be replaced before beginning ring-down spectroscopy on tropolone and other sample substances.
Professor Field and Dr. Haruki Ishikawa have recorded Stimulated Emission Pumping spectra (SEP) from the Č state of HCP to the 18,300 cm⁻¹ and 23,000 cm⁻¹ regions of the Ŵ state. Many combination levels were found. Some of these levels have very large rotational constants, due to a resonant Coriolis coupling between the CH stretch and the bending mode. This coupling indicates a large decrease in the CH stretch frequency at high excitation in the bending levels.

Professors Field, Robert J. Silbey and Steinfeld, Department of Chemistry and their associates have successfully performed an IR-UV double resonance experiment to characterize levels in the Ā state of acetylene that are forbidden by symmetry to be reached by only one photon. These states, in particular, one quanta of the anti-symmetric CH stretch, are important in our further studies of the isomerization of acetylene to vinylidene. From our previous studies, pumping one photon allowed states in the Ā state, allowed us to watch the flow of energy from the trans-bend into the cis-bend via a Darling-Dennison resonance, then with CC stretch the energy then flowed into states with anti-symmetric CH stretch by a 2,3,4,5-Fermi resonance. To see where the energy flows next, we need to start with a zero order bright state that contains at least one quanta of anti-symmetric CH stretch. The IR-UV double resonance allows us access to these zero order states. With the new purchase of a Princeton Instruments Intensified CCD, we are now in a position to record dispersed fluorescence from these new levels and, hopefully, further elucidate the energy flow dynamics in acetylene and their effect on the isomerization of acetylene to vinylidene.

Professors Field and Silbey and their associates are continuing the study of the 3¹A' electronic state (band origin ~50640) of HCP (Methinophosphide) and its isotopomer DCP through fluorescence-dip detected optical-optical double resonance spectroscopy. The K₃ structure of the various vibrational levels are being studied to shed some light on the Renner-Teller quasilinear behavior of the molecule in this electronic state.

Professor Mounj G. Bawendi of the Chemistry Department is studying the fluorescence properties of semiconductor nanocrystallites and heterostructures containing those crystallites. The SPEX Fluorolog has been used extensively for cw characterization of samples of II-VI nanocrystallites and for characterization of new polymer/crystallite heterostructures, including monolayers of crystallites deposited on a variety of substrates using Langmuir-Blodgett technology, and conducting polymer/crystallite structures. The electroluminescence spectrum tunes with crystallite size. The picosecond apparatus for time-correlated photon counting is now also being used to study carrier trapping processes in isolated crystallites and in crystallite heterostructures as a function of particle size and temperature (1.6 K to room temperature). We have time resolved the relaxation process on the 100psec to 5 nsec time scale by following the vibrational structure of the luminescence.

Professor Lippard, Department of Chemistry and his associates have continued to investigate the oxidative pathway of methane monooxygenase (MMO) and small molecule diiron complexes by stopped-flow methods. Dr. Stephen P. Watton has used stopped-flow spectroscopy to study ligand substitution for coordinated solvent molecules in a dinuclear ferric model compound. Resonance Raman spectroscopy has been applied to study metal-peroxo species in the reaction of cobalt(II) and iron(II) complexes with dioxygen. This method has also been used to confirm the presence of a metal-metal quadruple bond coordinated to a calixarene ligand and to investigate the effects of different solvents on the vibrational properties of this complex.

Professor Nelson, Department of Chemistry, and his associates are primarily interested in the ultrafast dynamics of the liquid phase. In particular, they focus on the behavior of low frequency vibrational ( hindered rotational) modes in the liquids. Using an ultrafast transient grating technique or the ultrafast optically heterodyned Optical Kerr Effect, they can observe changes in the relaxation dynamics as a function of pressure. Liquids such as formamide, carbon disulfide, and acetonitrile are used in these experiments because the small molecules have relatively simplistic structures that allow an intuitive understanding of pressure effects such as packing; therefore, these experiments will further knowledge of intermolecular interaction in the liquid phase.

Professor Ali S. Argon, Department of Mechanical Engineering, continues to study laser pulsed probing of mechanical properties of homogeneous and heterogeneous solids. Two of the most important applications involve: a) measurement of the tensile strength of planar interfaces characteristic of those encountered in composite materials between a fiber and its coating; and b) measurement of the elastic properties of micro-porous ceramics. In the first case the tensile strength of an internal interface is measured by a short wave length, high amplitude tension pulse. In the second case, related to reaction bonded silicon nitride with 75% density and a series of topologically interconnected pores of ca. 50-100 nm pore channels, the effect of such porosity on the elastic properties of the solid are being studied by a pulse-echo method of sound velocity measurement in thin samples. These techniques that lend themselves well to such measurements of fundamental properties have proven to be extremely useful in probing the internal constitution of some advance engineering solids.

Professor Wrighton, Department of Chemistry and his collaborators have been studying the dynamics of charge-separated states produced by photoexcitation in molecules and multicomponent polymers. The goal is to design ordered molecular assemblies capable of efficient formation of long-lived charge-separated states. A series of block polymers containing
either or both of two electron donors and a chromophore end group have been prepared and studied. Rational changes in the structure of the polymer have yielded increased charge-separated state lifetimes. In a related project the photophysics of a luminescent compound near an electrode surface (the compound is tethered to the surface via covalent bonds) is being studied. This work uses pulsed and continuous wave lasers to perform transient emission and absorption measurements.

Professors Klavs F. Jensen, Departments of Chemical Engineering and Materials Science & Engineering and Bawendi continued their work on spectroscopic characterization of CdSe-ZnSe quantum dot composite films deposited by electrospray organometallic chemical vapor deposition. Photoluminescence spectroscopy (on the Fluorolog 2) was employed in combination with other characterization techniques to optimize the new processing technology and assess the materials performance for optoelectronic applications. Efforts continue on the development of the composites, in particular, on enhancement of photoluminescent and electroluminescent efficiencies by surface derivatization of the CdSe quantum dots.

Professor Michael Rubner, Department of Materials Science and Engineering and Professor Bawendi have been studying quantum dots. Efforts continue on the development of the composites, in particular, on enhancement of photoluminescent and electroluminescent efficiencies by surface derivatization of the CdSe quantum dots.

Professor Steven R. Tannenbaum and Dr. Paul L. Skipper, Department of Chemistry/Division of Toxicology and Drs. Dasari and V. Bhaskaran Kartha of the Spectroscopy Laboratory have developed a cryogenic laser fluorescence method for sub-femtomole quantitation of protein and DNA adducts of the carcinogen B(a)P. Several samples of histone adducts of B(a)P from lymphocytes and lung tissues have been analyzed by this method. Concentrations of adducts have been found to be in the range of 0.01 to 1 pmol/mg histone, in good agreement with expectations based on BPDE-DNA adducts and ratio of DNA-histone binding.

Professor Alexander Rich, Department of Biology and his collaborators have identified Z-DNA forming regions in the c-myc oncogene by using the Nd-YAG laser at 266 nm to induce specific cross-links with an anti-Z-DNA antibody. Work in progress is designed to extend these findings by expressing in U937 cells a single chain anti-Z-DNA antibody to study formation of Z-DNA in lung cells. In addition, proteins that bind to the Z-DNA forming regions are being identified, so that their effect on c-myc gene expression can be examined in vivo.

Professor H. Gobind Khorana, Department of Biology and Chemistry and his colleagues, Drs. Cheng Zhang and David Farrens, studied the biological photoreceptor, rhodopsin, which is a model system for a large family of G-protein coupled biological receptors. Their aim is to understand how chromophore isomerization, which occurs in the membrane-embedded helices, is translated into conformational changes at the exterior of the rhodopsin protein. Rhodopsin mutants will be used with spectroscopic labels at unique positions in the protein. These labels will be used to detect motion in the helices after retinal isomerization.

Professor Tanaka, Department of Physics and his coworkers have been studying the macroscopic behavior of polymer gels to understand the principles with which proteins and polypeptides can memorize a unique conformation and to have functions of molecular recognitions, catalysis, and motion. The gels were found to undergo volume phase transitions among more than two stable states which are specified by a set of discrete degrees of gel swelling. In order to understand molecular interactions in different phases, FTIR and FT Raman spectroscopic studies have been carried out on the mixtures of dimethylacrylamide (DMAAm) and methacrylic acid (MAAc) at different compositions. Spectra of these mixtures showed new features which were attributed to hydrogen bonding.

Professors David E. Pritchard and Wolfgang Ketterle, Department of Physics have demonstrated evaporative cooling of sodium atoms, for the first time, with laser-cooled atoms. The requirement for evaporative cooling is a high initial density, which was obtained by using a dark light trap, then transferring the atoms into a magnetic trap and adiabatically compressing them. Evaporative cooling might lead to the lowest temperatures ever obtained and to the observation of novel quantum-statistical effects.

Prof. Daniel Kleppner of the Department of Physics and his coworkers have conducted experimental studies of lithium in an electric field that reveal the signature of very long period orbits in a regime of disorderly motion. In addition, they have observed for the first time bifurcations of classical orbits of an atomic electron in an electric field. These bifurcations provide a natural way of understanding the evolution of the spectrum from a broad sinusoidal oscillation at positive energies to a quasi-discrete spectrum below the classical ionization limit.
Professor Feld and Dr. Dasari and their colleagues have recently succeeded in realizing laser oscillation with less than an average of one atom in a single mode resonator. Even with less than one atom, about one photon on average could be sustained inside the resonator by the stimulated emission process. The experimental results of this "microlaser" system are in good agreement with an one-atom quantum theory. They are also continuing an experiment to observe an unusual two-peak fluorescence spectrum in a weakly coupled atom-cavity system where no energy exchange between the cavity mode and atom is possible.

Professor Ali Javan, Department of Physics and Dr. Michael Otteson continue to explore metal-oxide-superconductor junctions. This type of nonlinear element should ultimately permit single-step frequency-mixing throughout the spectral region of interest. Direct frequency transfer will be possible from a near-IR frequency to a near-UV frequency, or a direct single-step frequency-transfer from a near-IR to a microwave frequency, a significantly less complex system than the previous multi-stage systems. Direct frequency transfer measurements are currently underway in the Laboratory.

Professor Feld, Dr. Ramasamy Manoharan and their collaborators at Cleveland Clinic Foundation (CCF) and Brigham and Women's Hospital (BWH), have continued the application of laser induced fluorescence (LIF) spectroscopy for diagnosing disease. In collaboration with Dr. John Kramer, Department of Cardiology, CCF, they are investigating the potential of LIF for guiding laser surgery of atherosclerotic plaques in coronary artery. In collaboration with Dr. Robert Cothren of the Department of Biomedical Engineering, CCF, they have successfully modeled tissue fluorescence collected at the clinical setting. Microspectroscopy, microscopic imaging, light scattering analysis and Monte Carlo simulation have been used to develop this molecular based model. This model provides opportunities for predicting fluorescence from tissues in other clinical settings, guiding ways to increase the discrimination between normal and diseased regions, and building robust diagnostic algorithms. Also in collaboration with Dr. Cothren, and Dr. Eric Klein, Department of Urology, CCF, Dr. Howard Levin, Department of Pathology, CCF, they are developing spectral-based algorithms for diagnosing bladder cancer at cystoscopy.

Professor Feld, Drs. Dasari, Manoharan and Yang Wang of the Spectroscopy Laboratory, in collaboration with Drs. Jacques Van Dam and John Gollan, Division of Gastroenterology, BWH, and James Crawford, Department of Pathology, BWH, are developing laser induced fluorescence for diagnosing precancerous changes in colon at routine endoscopy. Initial clinical studies explore the use of contact probe technology for detecting localized lesions and for guiding tissue biopsy. In the second application, they are developing fluorescence endoscope imaging systems for surveillance of disease in wide area of the colon. Clinical studies utilizing this technology will soon begin.

Professor Feld and Drs. Dasari, Irving Itzkan and Wang, and Dr. Lev Perelman of the Spectroscopy Laboratory, have been exploring the potential of optical tomography for biomedical applications. In the past year, significant progress has been achieved in three areas of the research. They applied the concept of a path-integral approach to explain the physics of photon migration processes inside a turbid media. They illustrated experimentally the photon paths, suggested by the above theory, by time-resolved and single-photon detection of scattering light. Finally, they developed a single-ended technique for three-dimensional imaging of objects embedded in a turbid medium using time-resolved fluorescence emission or Raman scattering.

Professor Feld and Drs. Dasari, Manoharan and Wang have been continuing the research effort of applying Raman spectroscopy to histochemical analysis of human disease. Major research efforts have focused on quantitative histochemical analysis of human arterial lesions in vivo by near-infrared Raman spectroscopy. This project is conducted in collaboration with Dr. Kramer. In addition, they have also been conducting research in the areas of application of ultraviolet resonance Raman spectroscopy for detection of human colon dysplasia and the detection of dissolved gases and blood constituents non-invasively.

Professor Feld, Drs. Itzkan and Perelman are developing a new approach to the theoretical understanding of the mechanism of the laser ablation of biological tissue by short pulses. They have termed the mechanism "inertially confined ablation" because the tissue does not have time to move during the laser pulse, thereby generating large stresses rather than high temperatures. The thermoelastic wave equation has been solved in a three-dimensional geometry to determine the magnitude and spatial location of these stresses. It is the high stresses which then causes the tissue to disassemble and ablate, rather than thermally vaporize.

Professor Feld and Dr. Itzkan are exploring the fundamental mechanisms of inertially confined ablation of biological tissue using various experimental techniques. A newly developed interferometric technique allows the monitoring of events initiating the ablation process on a nanosecond time scale. These experimental results allow the optical, thermal, and mechanical properties of the tissue to be determined and the stresses to be calculated. These results, coupled with the theoretical program, will be important in designing lasers for microsurgical applications.
The Laboratory for Nuclear Science (LNS) provides support for research by faculty and research staff members in the fields of high energy and nuclear physics. These activities include those at the Bates Linear Accelerator Center and in the Center for Theoretical Physics. Approximately half of the faculty in the Department of Physics conduct their research through LNS. During fiscal year 1994, the Department of Energy is expected to provide LNS a total of $27,820,000 in research funding.

EXPERIMENTAL HIGH ENERGY PHYSICS

LNS researchers in experimental high energy physics are active at a number of laboratories around the world, including CERN (Switzerland), Gran Sasso (Italy), BEPC (China), and the US accelerator facilities SLAC (California), Fermilab (Illinois), and Brookhaven (New York). The overall objective of current research in high energy physics is to test as precisely as possible the Standard Model, which has been so successful in describing a wide variety of phenomena, and to look explicitly for physics beyond the Standard Model. In recent years such precise tests and searches have required in general very large and complex detectors measuring results from collisions of extremely high-energy particles. The laboratories listed above have a variety of complementary capabilities to address critical questions in particle physics. LNS researchers are playing leading roles in many of these experiments, as described below.

The L3 experiment at CERN is the largest of four detectors at the Large Electron Positron (LEP) Collider, which is the highest energy such collider in the world. The aim of the experiment is to deepen our knowledge of the Standard Model by measuring with high precision the properties of the intermediate vector bosons, Z and W, their couplings to other particles and, perhaps, the mechanism of spontaneous symmetry breaking, while keeping open the possibility of finding new phenomena beyond the Standard Model. This project has been led from the beginning by an LNS group, and broke new ground in bringing together a large number of scientists from many countries into a highly successful collaboration. So far L3 has provided many important tests of the Standard Model. These include precise measurements of the properties of the Z0 particle (the carrier of the neutral electroweak force); demonstration, by two independent methods, that there are only three types of light neutrinos in the Universe; limits on the possible masses of the top quark and the Higgs boson; and the measurement of the strong coupling constant α. The capability of the L3 detector to study photons with great precision showed its benefit when events were recently found which may indicate the presence of an unexpected particle with mass around 60 GeV/c². As more data are analyzed, an excess of events near 60 GeV/c² continues to exist. L3 has recently upgraded its experiment with the installation of a precise vertex detector, and is in the process of implementing greater coverage for muon detection. Both of these upgrades will be critical especially when LEP doubles its energy during the next several years. At that time it will be possible to study in detail the properties of the W± particle, the carrier of the charged electroweak force.

LNS researchers are playing a leading role in exploiting the unique properties of the SLD detector at SLAC. With micron size beams, very high resolution vertex detection, excellent particle identification and calorimetry, and a polarized electron beam, SLD is making important contributions to the precise determination of Standard Model parameters and to our understanding of heavy quark physics. The first measurements of the left-right cross section asymmetry, ALR, for Z0 boson production using polarized electrons have been completed. The measurements of ALR have yielded a determination of sin²(θW)eff, the effective weak mixing angle, fully competitive with measurements elsewhere. A continuing run will permit the most precise measurement of sin²(θW)eff attainable with current high energy physics facilities.

The Collider Detector Facility (CDF) Experiment at Fermilab is designed to study the Standard Model and its possible extensions at the highest energy accelerator in the world, the Tevatron $\bar{p}-p$ collider.
The most important result obtained during the last year was evidence for the existence of the top (t) quark at a mass of $174 \pm 10^{12}$ GeV. The MIT group played an important role in the development of the analysis which led to this result. The number of events in the data sample is small and the result is not yet definitive. The experiment is currently running and acquiring new data. The CDF group expects to increase the data sample three to fourfold over the next year. Other objectives of CDF include studies of the b quark, the low mass partner of the t quark; precision measurement of the mass of the W, the charged intermediate boson; and the search for possible quark sub-structure. Until the construction of a European high energy hadron collider (LHC) at CERN the Tevatron at FNAL represents a unique capability for particle physics at the highest available energies.

A recently established LNS activity is a search for the "axion," a particle predicted to exist by a minimal extension of the theory of strong interactions and a possible solution to the "dark matter" problem in cosmology. This research, at the intersection of particle physics, astrophysics, and cosmology, is the major focus of one of our junior faculty members. Data-taking for this search is expected to start by the end of the year.

Smaller LNS efforts in experimental high energy physics include work at the underground facility at Gran Sasso, in which a number of problems in particle physics and astrophysics can be studied. Such experiments are an important complement to accelerator-based projects. Another project at Brookhaven is designed to search for "strangelets," an exotic form of matter allowed by QCD. Analysis of data taken at BEPC is well along and LNS involvement in this experiment will soon be completed.

Following termination of the SSC project, LNS is now involved in both detector initiatives at the LHC, viz., the CMS and ATLAS efforts. In CMS, LNS scientists are engaged in the development of the data acquisition and muon detection systems. In ATLAS the effort is mainly in the development of the muon detection systems. LNS scientists have considerable expertise in both data acquisition and muon detection systems and expect to become major participants in the U.S. efforts at the LHC.

**EXPERIMENTAL NUCLEAR PHYSICS**

Experimental nuclear physics at present has two main thrusts: medium-energy physics and heavy-ion physics. LNS has active, leading groups in both of these sub-fields.

The focus of medium-energy activities is of course the Bates Linear Accelerator Center, which is operated by LNS for the Department of Energy as a national user facility. Bates has been a premier national and international resource for nuclear and particle physics studies for two decades. A major upgrade of its capabilities, the South Hall Ring, is now being commissioned. This upgrade will allow both external and internal-target experiments using the continuous (as opposed to pulsed) beam from the Ring. The continuous nature of the beam is critical for a number of experiments, such as those using coincidence techniques.

Even during the construction of the South Hall Ring, a limited experimental program at Bates has proceeded. Several experiments have concentrated on the use of the $^3$He nucleus as a target. An important reason for the interest in $^3$He is that it can be polarized, and the resulting polarization comes primarily from the spin of the unpaired neutron. Polarized $^3$He thus serves approximately as a neutron target for experiments which measure polarization observables. A recent successfully completed experiment measured the quasi-elastic scattering of polarized electrons from a polarized $^3$He gas target. It provides direct information on the neutron charge distribution. Another major experiment currently underway uses parity violation in electron-proton scattering to access new information on the importance of strange quarks in the structure of the nucleon.

In addition to the new capabilities provided by the South Hall Ring, Bates is completing or planning the construction of several major new detectors. The Focal Plane Polarimeter is now being used for experiments which require measurement of outgoing proton polarization. The Out-of-Plane
Spectrometer is partially complete and has already been used for experiments. Construction of the Bates Large Acceptance Spectrometer Toroid is expected to begin later this year. These new experimental capabilities will provide an unprecedented opportunity to address critical issues in medium-energy physics.

LNS researchers are also leading several important efforts at accelerator facilities other than Bates. These facilities are LAMPF (New Mexico), IUCF (Indiana), CEBAF (Virginia), DESY (Germany), MAINZ (Germany), and PSI (Switzerland). This research includes an experiment at DESY to study the spin structure of neutrons and protons, using a polarized $^3\text{He}$ target constructed at MIT. It also includes experiments which use pion-nucleus interactions to study Quantum Chromodynamics (QCD) in the non-perturbative and perturbative regions. The IUCF efforts are closely connected to the question of whether the polarized $^3\text{He}$ nucleus is effectively a neutron target, which is of course of considerable importance to the Bates program. LNS researchers are leading the design and construction of detectors for experiments at other facilities, such as CEBAF.

LNS is also a leader in the field of heavy-ion physics. In recent years the emphasis has been on studies of relativistic interactions of heavy-ion projectiles, especially as they may shed light on the question of the existence and properties of the quark-gluon plasma. This new state of matter is predicted to exist at temperature and densities higher than those present in normal nuclear matter, but which may exist for a brief time in collisions of heavy ions. The LNS group is the leader of one of the few experiments (called PHOBOS) approved for the Relativistic Heavy Ion Collider (RHIC) under construction at Brookhaven. A new initiative of the group is a search for the possible creation of a new state of the vacuum, using Pb-Pb collisions at CERN.

THEORETICAL NUCLEAR AND PARTICLE PHYSICS

Research at the Center for Theoretical Physics seeks to extend and unify our understanding of the fundamental constituents of matter and the theory that governs them. In addition, it uses our present knowledge of this theory to advance our understanding of a variety of subjects, including the structure and interactions of hadrons and nuclei, new forms of matter which may be created experimentally or observed astrophysically, and the behavior of the early universe.

String theory aims to unite the strong, electroweak, and gravitational interactions and to explain the observed hierarchy of particles and interactions. An important contribution at MIT has been the development of a general field theory of closed strings. It has recently been shown that this theory is independent of the background field that is used in its construction. Finite temperature effects have been incorporated into string theory, leading the way to the study of cosmology and radiation from black holes.

Topological terms in field theories, which were introduced by this group several years ago, are now widely studied in problems ranging from gravity to high temperature superconductivity. Recently, these terms were shown to play an important role in QCD at high temperature and used to understand the response function in the quark-gluon plasma.

A striking feature of general relativity is the existence of particle trajectories that travel backwards in time. Although such trajectories exist as formal solutions, the systems allowing such solutions have been shown, in the cases which have been studied, to be unphysical or impossible to create from physically acceptable initial conditions.

The role of underlying quark and gluon degrees of freedom in hadrons, hadronic interactions, and nuclear structure is of fundamental interest. New formulations of Yang-Mills gauge theory have been developed in terms of gauge-invariant variables, and the possibility of observing new multiquark resonances in hadron scattering has been studied.
A major recent thrust has been in the area of lattice gauge theory, which provides a unique tool to solve, rather than model, QCD. Recent lattice solutions have provided strong evidence that the structure of nucleons, pions, and other light hadrons is dominated by topological excitations of the gluon field. To exploit the fundamental opportunities in this field, a development project to build a Teraflops computer at MIT is underway in partnership with the Laboratory for Computer Science, Thinking Machines Corporation, Lincoln Laboratory, and a national collaboration of physicists.

MIT has played a pioneering role in exploiting high energy scattering to determine the quark and gluon structure of nucleons and nuclei. Significant new developments have been the determination of the behavior of structure functions in the new regime to be studied at CEBAF, the discovery of new ways to measure spin dependent structure functions, and the first successful theory of the fragmentation function for pions.

CTP theorists have developed extensions of the Standard Model, including extended Technicolor and supersymmetric models, which agree with known data and make testable predictions. Developments in heavy quark physics have been used to find new ways to study CP violation in B meson mixing, and to determine weak matrix elements from B decays.

Electroweak interactions are a continuing focus of research. The unique opportunities provided by the new ring at the Bates accelerator have motivated studies of reaction mechanisms, of new ways to use nuclei to test fundamental symmetries, and of spin and polarization observables. The use of neutral current probes to study the strange quark content of the nucleon has been studied. Anti-neutrino and heavy-flavor neutrino production from the sun have been studied to obtain new information on the solar neutrino anomaly and neutrino mixing.

Efforts have continued to understand the nature of periodic solutions in multi-dimensional classical systems and their implications for quantum chaos, and the first periodic solutions for many-fermion systems have been obtained numerically. Nuclear reaction theory has been used to explain the parity violation observed experimentally in low energy neutron scattering and the compound nucleus enhancements in photon production by proton-nucleus scattering.

EDUCATION

Since its founding LNS has placed education at the forefront of its goals. At present approximately 85 graduate students are receiving their training through LNS research programs. A number of undergraduate students are also heavily involved in LNS research. Evidence shows that LNS educates a significant portion of young scientists nationally in nuclear and high-energy physics.
FACILITIES
The George R. Wallace, Jr., Astrophysical Observatory is a teaching and research observatory located in Westford, Massachusetts. Its facilities consist of a 24-inch telescope, a 16-inch telescope, several 14- and 8-inch telescopes, a 5.5-inch astrograph, and a small building that houses a workshop, darkroom, computer facility, and observers' quarters. Instruments include the "SNAPSHOT" high-speed dual-CCD photometer, several small CCD systems (a Photometrics Star 1 and two Spectrasource Lynxx systems), conventional photometers, photographic cameras, and a spectrograph.

Upgrades to Observatory facilities during the past year included the acquisition of a portable high-speed CCD occultation system. We have also made progress on the conversion of the spectrograph from 35-mm film to CCD technology. The undergraduates working on this project—Aki Roberge and John-David Smith—are participating in the Undergraduate Research Opportunities Program (UROP) and are being supported by NSF's Research Experiences for Undergraduates. New work benches have been installed in the building housing the smaller telescopes. The Observatory also purchased a new van to replace its old model, which was unreliable and was starting to become a potential safety risk for students. The van is used to transport students and equipment to and from the MIT campus, and to transport liquid nitrogen from Haystack Observatory to the Wallace site for the SNAPSHOT CCD.

PERSONNEL
Professor James L. Elliot continued his duties as Observatory Director. Principal Research Scientist Heidi B. Hammel assists with site management and telescope scheduling, with the help of Research Specialist Rich Meserole. Mr. Michael Mattei was recently hired as a part-time Technical Assistant for making on-site observations and helping with optical maintenance. Other staff is coordinated through research programs (see below).

ACADEMIC ACTIVITIES
Last year the subject 8.287J-12.110J (Observational Techniques of Optical Astronomy) drew about 15 students, who used the Wallace facilities to do a variety of astronomical projects. An additional 20 students in subject 12S23 (Observing the Stars and Planets) used the Observatory for laboratory work. Course 12S24 (Advanced Observations of Stars and Planets) was not offered this year. An informal field trip for course 12.401 (Beyond the Solar System) was attended by 8 undergraduates. An open house held during MIT's 1994 Independent Activities Period attracted over 40 people. Most were MIT undergraduates; some faculty and staff from other departments came. Another open house was held for a local elementary school group. About 35 people (including siblings, friends, parents, and teacher) attended.

RESEARCH PROGRAMS
Reba Bandyopadhyay, Stephen McDonald, and Catherine Olkin used the Observatory's 24-inch telescope to obtain CCD data for astrometric fields surrounding the comet 2060 Chiron and the star Ch08, which Chiron occulted this past March. Professor Elliot, Ms. Olkin, and their colleagues successfully observed this occultation with NASA's Kuiper Airborne Observatory, and they found several features of moderate optical depth, which may be signatures of jets from Chiron's nucleus.

Graduate Student Jeff Foust is using the Wallace 24-inch and 16-inch telescopes to prepare our new portable high-speed CCD system for observations of the collision of Comet Shoemaker-Levy 9 with Jupiter, which will occur in mid July 1994. Mr. Foust will be taking our system to the Planetary Patrol Telescope at Mauna Kea Observatory (Hawaii) to observe the event. Ms. Bandyopadhyay and Undergraduate Lisa Sopata will monitor the event at Wallace using the SNAPSHOT on the 24-inch. Ms. Roberge and Mr. Smith will observe it with the spectrograph on the 16-inch.

Graduate Student Steve Slivan, working with Professor Richard Binzel, used the Wallace 24-inch telescope to observe the rotational lightcurves of asteroids Lacrimosa, Dresda, Urda, Florentina, Claudia, Eriphyla, Koronis, and Elvira for his doctoral dissertation. He is developing an extensive database of asteroid photometry with the Wallace facilities. Mr. Slivan and Professor Binzel also provided groundbased reconnaissance of the asteroid Ida, which was the target for a fly-by with Galileo spacecraft in August 1993.

Mr. McDonald, Ms. Bandyopadhyay, and Ms. Olkin also used CCD data from the 24-inch for astrometric and photometric observations of other occultation candidate stars for events involving Pluto, Saturn, Jupiter, Uranus, Neptune, Triton, and Titan. Astrometric and photometric observations in support of the Hubble Space Telescope are continuing, with Dr. Amanda Bosh (Lowell Observatory) assisting in coordination of that effort.

HEIDI B. HAMMEL
THE FACULTY POLICY COMMITTEE

This year the Faculty Policy Committee (FPC) continued to oversee those aspects of educational and academic policy that are specific responsibilities of the faculty and to provide faculty input into policy development at the Institute. This year, as in recent years, MIT has undergone budgetary and structural shifts in response to external and internal forces. In particular, changes in MIT's relations with the federal government and the need to curb escalating operating costs have raised difficult questions, and at times the Institute has come up with some controversial answers. In 1993-4, the FPC tried to prioritize faculty concerns in the budget discussion and also provide a clear and reasoned faculty voice during animated debate on issues that run the gamut from faculty retirement to snow closings.

The President and the Chair of the Faculty appointed faculty committees to review two major administrative decisions, with each committee reporting to the President and FPC before making a full report to the Faculty:

1) A committee reviewed the process behind the decision to move the Department of Brain and Cognitive Sciences (BCS) from the Whitaker College of Health Sciences and Technology to the School of Science. While the decision to move BCS was uncontroversial, the decision-making process marked the first time the Institute carried through the newly developed procedures governing the reorganization of an academic unit. The guidelines were developed in the late 1980s by the Widnall Committee in response to the closing of the Department of Applied Biological Sciences.

In accordance with Section 1.32 of Policies and Procedures, the President and the Chair of the Faculty at the time, J. Kim Vandiver, appointed an ad hoc faculty committee to review the process leading up to and following the BCS decision. At the October 1993 Faculty Meeting, committee chairman Professor Paul Penfield outlined a number of flaws in the process, none of which the committee considered serious. The FPC praised the Penfield Committee for its work, noting that the review process set forth by the Widnall Committee had worked as intended. The Penfield Committee's report will be preserved as a resource for future committees conducting similar reviews.

2) The Provost's decision to close the Center for Materials Research in Archaeology and Ethnology (CMRAE) and the subsequent distribution of a pamphlet, An Institute in Ruins, by the Center's director, Professor Heather N. Lechtman, generated considerable concern among the faculty. Many faculty were concerned about the appropriateness of closing the Center as well as the process by which that decision was reached. The President and the Chair of the Faculty appointed an ad hoc faculty committee chaired by Professor Peter A. Diamond to examine the process followed in arriving at the decision to close the CMRAE. At the March meeting of the Faculty, it was resolved that the decision to close the CMRAE be set aside until the Diamond Committee reported to the Faculty.
The Diamond Committee reported to the President and the Chair of the Faculty and presented its report to the Faculty at its May meeting. The report identified a number of significant flaws in the decision-making processes and the way in which the decision was communicated to the affected parties. These flaws affected processes used by the Provost's Office and by those associated with the original review of the CMRAE in March 1993, which was conducted by a committee appointed by the Provost and chaired by Professor Peter Perdue. The Perdue Committee included faculty inside and outside of MIT. This committee's report did not fully represent the members’ range of views about the future of CMRAE, which may have been due, in part, to confusion about the purpose of the review. The process was further tainted by residual bitterness from an earlier disagreement between the Center and the School of Humanities and Social Sciences, and insufficient communication between the Provost’s Office and other members of the consortium of which the CMRAE is part.

The Diamond Committee was unequivocal, however, in its finding that the Provost's decision to close the Center was made with full knowledge of the many divergent views about the possible future of the Center. It did not recommend reversing the decision.

The Diamond Committee noted that past decisions to close a center or laboratory have not been subject to the same faculty oversight as the reorganization of an academic unit. It concluded that establishing a new set of procedures for laboratories and centers would be too constraining, given their diverse nature at MIT. The Committee made a number of recommendations focused on providing a better mechanism for administration consultation with faculty and students who would be affected by the closure of centers or laboratories. These recommendations will be considered by the FPC this fall.

When the FPC met to review the Diamond Committee report, two concerns were raised: 1) other interdisciplinary centers would be particularly vulnerable to budget cuts, and 2) faculty members who are asked to take on reviews such as this should receive adequate guidance and instruction beforehand. Overall, the FPC concurred with the Diamond report's conclusions and praised the committee for its fine work.

MIT's relations with the federal government continued to dominate Institute business, and the FPC's agenda often reflected these issues.

- President Charles M. Vest visited the FPC twice to discuss the goals he set for himself in last year's President's Report and to discuss a broad spectrum of issues. Both times the discussion turned to budget and federal relations issues. The breakdown of the strong partnership between research universities and the federal government created educational and financial crises as funding for many areas of research has been reduced. MIT's budget imbalance correlates strongly with the loss of federal support, and consequently the Institute has had to increase its reliance on tuition, gifts, and endowment income. FPC members were particularly interested in MIT's evolving industrial and corporate relations and encouraged the President to pursue these opportunities. At the same time
members of the FPC raised concerns that MIT not lose sight of its traditional goals of providing students with the best analytical education and pursuing world-class, curiosity-driven research. The FPC expects to have frequent contact with the President next year as the Institute grapples with budget issues through reengineering.

- The FPC met with Provost Mark S. Wrighton to discuss the progress of MIT’s continuing struggle to restructure its budget in response to rising costs and fragile federal support. The Provost underscored the seriousness of the budget situation, noting that a further reduction in the size of the MIT faculty is possible. The FPC noted the connection between downsizing the faculty and faculty retirement patterns in response to the end of mandatory retirement on January 1, 1994.

The government’s decision to apply overhead and benefits charges to the Undergraduate Research Opportunities Program (UROP) funds was particularly troubling. The new charges will cut in half the funds available for UROP students. At the suggestion of the FPC, the Provost assembled a working group of faculty and students to help him persuade officials in Washington to reverse their decision. This group achieved some initial success, convincing MIT’s cognizant agency to reduce the employee benefits rate on UROP salaries to a nominal level. Further actions will be taken in 1995.

- Professor Robert Weinberg briefed the FPC on the conclusions of the Committee on Indirect Costs and Graduate Student Tuition. Charged with assisting the Provost in finding innovative ways to offset the $13 million expense created by changes in federal reimbursement procedures, the Weinberg Committee was dismayed to report that any moves to increase revenue would lead to a reduction in the number of graduate students. The practice of charging graduate student tuition to the benefit pool resulted in a surge in the number of graduate students on campus in the early 1980s, and the Weinberg Committee concluded that scaling back the number of students to the somewhere near the previous level may be the only way of offsetting the shortfall. The Weinberg Committee reported its findings at the November Faculty Meeting.

- The FPC joined the rest of the Institute in its celebration of the Justice Department’s decision to drop its anti-trust suit against MIT. The dismissal resulted in the partial reopening of communication among schools on student financial aid packages. Under the terms of the agreement, MIT will be able to continue its policy of need-blind admissions while maximizing the effectiveness of its financial aid dollars.

FPC also heard from and coordinated the work of several other committees:

- At the request of the Chair of the Faculty, the Committee on Faculty-Administration (CFA) undertook an in-depth review of the questions facing the Institute regarding faculty retirement. This review is part of a larger effort by the MIT administration to respond to the expiration of mandatory retirement for tenured faculty on January 1, 1994. Some are concerned that the end of mandatory retirement will cause many faculty to stay on beyond age 70, which may result in the loss of resources normally used to hire young faculty.
The CFA made three recommendations to the FPC regarding retirement policy: 1) implement only those changes in the Retirement Plan that are not disincentives for retirement; 2) provide as much flexibility as possible in the use of Plan assets for individuals who retire; and 3) create novel work options which allow seniors to continue to serve while obtaining flexible plan benefits. FPC concurred with these recommendations and passed them on to the Steering Committee on the Strategic Review of Benefits (SRB). Both the CFA and FPC will continue to work on aspects of this issue next year.

- The Committee on the Undergraduate Program (CUP) discussed with FPC its recommendations about proposed changes to the Humanities and Social Sciences Distribution Requirement (HASS-D). A review of HASS-D by CUP was mandated by the Faculty in its 1987 restructuring of the undergraduate Humanities Requirement. A review committee was appointed in the Schools of Architecture and Planning and Humanities and Social Sciences and reported its conclusions to CUP. Although the CUP and the HASS-D review committee disagreed about the revised configuration of the required HASS-D subjects, deliberations continue between the two committees so that a final proposal will be ready for presentation to the Faculty next year.

- Professor Jack L. Kerrebrock visited the FPC to discuss the work of the Family and Work Council. The Council’s immediate goal is to recommend programs and changes that can be implemented in the current era of diminishing financial resources. Its future plans include a closer look at child care referral services and facilities at MIT and the possibility of a flexible work rule that will allow employees to maximize their well-being and productivity.

The FPC reviewed several changes in academic policy and general procedures, some of which were forwarded to the Faculty for approval:

- The Sloan School of Management, with the approval of the Committee on Graduate School Policy (CGSP), restructured its primary degree program. As approved by the Faculty, the new degree will be titled Master of Business Administration (MBA). The restructured degree replaces the traditional 24-unit thesis with additional course work including significant research projects. The Master of Science in Management degree would still be awarded to students who complete a 24-unit thesis. The introduction of a graduate degree without a required thesis caused some concern among FPC members who worried that this reflects a larger trend toward de-emphasizing significant research experience as a degree requirement. Sloan School faculty, however, argued that this change reflects the professional nature of the Sloan degree, which is often listed as an MBA by graduates on their résumés. They also emphasized the extensive research experience already embedded in the regular curriculum. Other Sloan programs, such as Leaders for Manufacturing, will continue to require a thesis. The Faculty approved the restructured degree and title at its February meeting.

- The Department of Ocean Engineering developed a proposal for a Master of Engineering (M.Eng.) degree in Marine Environmental Systems. This proposal was the first to come before the Faculty following the approval in 1992 of M.Eng.
degrees in general and the degree in Electrical Engineering and Computer Science in particular. It raised a number of concerns about the proliferation of five-year degree programs at the Institute. The FPC approved the new program and will make a report to the Faculty in the fall, but it was clear from the deliberations with the CGSP and the Department of Ocean Engineering that the approval process for new degrees requires clarification.

The FPC asked Dean of the Graduate School Frank E. Perkins and the CGSP to recommend more specific procedures for approving new graduate degrees and significant curricular changes. Further clarification is required of the distinctions between curricular changes, which are the domain of the CGSP, and changes that affect the Rules and Regulations of the Faculty, which must be reviewed and approved by the FPC and the Faculty. This is especially important in the case of M.Eng. degrees because they involve both undergraduate and graduate study. Dean Perkins and the CGSP will work with the FPC to formulate policy on these matters in the fall, at which time other M.Eng. degrees are expected to come before the Faculty.

- The CUP reported its decision not to renew the HASS-D take-home finals experiment. The experiment was approved two years ago in response to unhappiness on the part of faculty who teach HASS-D subjects, which had been required by the HASS-D Overview Committee to give scheduled final exams. In the course of its review of the HASS-D Requirement, the CUP accepted the recommendation of the HASS-D Review Committee that final exams no longer be required in HASS-D subjects. Thus the need for an exception to the Faculty Rules (which prohibit take-home finals of any kind) no longer existed and the experiment was terminated.

- The FPC formed a subcommittee to review proposed changes to the terms of appointment for adjunct faculty. The proposal originated in the School of Engineering to allow Schools more flexibility in hiring experienced practitioners from industry on a temporary basis. Last fall, the FPC reviewed Dean Joel Moses' proposal and appointed a subcommittee to delve deeper into the issue. This spring the subcommittee made a series of recommendations which were forwarded to the Academic Council for review. After a thorough discussion at Academic Council, minimal changes were made in the existing policy, which, it was felt, allows considerable flexibility. These changes will be reported to the Faculty early this fall.

- Several issues involving student academic dishonesty came before the FPC. The Committee worked with Dean for Undergraduate Education and Student Affairs Arthur C. Smith and the Committee on Discipline (COD) to establish new procedures for reporting to the Faculty on student disciplinary proceedings. A model was developed that presents considerable information on allegations and sanctions but protects the privacy rights of individuals. With the approval of the Committee on Privacy, information regarding disciplinary proceedings for 1992-3 was presented at the February Faculty Meeting.
Undergraduate Education and Student Affairs' (ODUESA) office and student representatives was asked to review the report on academic dishonesty titled *Undergraduate Academic Dishonesty at MIT: Results of a Study of Undergraduates, Faculty and Graduate Teaching Assistants*, which was distributed in November 1993. The group was asked to recommend changes in announcements of expectations of academic honesty, Institute policy regarding "bibles," and procedures for handling incidents of academic dishonesty. A report is expected this fall.

- At its May meeting, the Faculty asked the FPC to reassess MIT's faculty grievance procedures. The motion voted by the Faculty noted that there are no specific procedures for faculty members who wish to file a grievance against the MIT administration and asked the FPC to consider establishing a standing faculty committee to handle such complaints. The FPC will undertake this review next year.

The FPC also discussed several issues and events with a broader impact on MIT:

- The FPC reviewed the Institute's progress on harassment issues. The distribution of a new guide *Dealing with Harassment at MIT* marked a significant step toward eliminating harassment. The FPC discussed the community reaction to the distribution of the guide and urged the student members to use their organizations to develop specific recommendations for improvements in the guide and the Institute's policy. The FPC emphasized that all faculty members are supervisors and hold special responsibility for preventing and being sensitive to incidents of harassment. The Committee commended Associate Provost Samuel Jay Keyser on his efforts to train faculty and staff in methods of complaint handling and urged that this process continue.

Later in the year, the Graduate Student Council presented to the FPC a set of recommendations for improving procedures outlined in the guide, and FPC formed a subcommittee to refine and implement their recommendations. The subcommittee has developed means for implementing the recommendations and will report to the FPC and the community in the fall.

- The FPC noted that the Institute Pornography Policy expired in February 1993. Established in February 1990, the policy contained a three-year sunset clause. After considerable discussion of the wisdom of having an explicit policy on pornography, the FPC agreed with the judgment of the Academic Council that problems which might arise could be effectively handled under the Institute's existing policies on harassment.

- The FPC devoted considerable time to discussing issues of cultural and racial diversity at the Institute. The committee recognized the need for greater understanding of these issues among faculty members and explored a number of ways to encourage faculty to interact on a personal level with students of varied backgrounds. FPC also supported establishing an Institute committee on race relations which would provide funding and leadership for activities that promote diversity and cultural understanding.
Dean Arthur Smith approached FPC to ask for increased faculty input on improving and restoring the Institute's classroom space. With the Committee's help, he formed an advisory committee to work with the administration on improving the maintenance, renovation, and creation of classroom space.

The FPC met with Professor Kim Vandiver to discuss programs underway in the newly established Edgerton Center. As the Center's Director, Professor Vandiver is continuing Doc Edgerton's legacy of giving undergraduates—particularly freshmen—a place where they can practice hands-on learning. The FPC was pleased and heartened to learn about the number and scope of activities at the Center, and it was noted that the Center's activities might be a springboard for revamping the Institute Laboratory Requirement.

The record-breaking snowfall this past winter and the ongoing capital improvements on campus raised a number of safety issues among FPC members, who were concerned about the safety of walkways and some inconsistency among departments about closing procedures during inclement weather. A small subcommittee was asked to look into pedestrian safety issues at the Institute. After meetings with representatives of the Campus Police, the Planning Office, and Physical Plant, the subcommittee made a brief report on projects underway and options for the future. A more extensive discussion is planned for the fall.

The FPC also began discussions on a number of issues that will continue into next year, including possible changes to Freshman Evaluation procedures, and the progress of a blue-ribbon panel reviewing medical services at MIT.

Finally, no account of the activities of the FPC would be complete without mentioning the loss of Constantine B. Simonides in April. His humor and wisdom graced the meetings of the FPC since its formation in the 1980s and those of its predecessor, the Committee on Educational Policy. Constantine played a key role in keeping the MIT faculty in touch with the administration, serving as liaison and confidant to many faculty chairs. His valuable advice and unending good humor will be greatly missed. His many contributions to the Faculty and the Institute at large were recognized through a formal resolution at the May Faculty Meeting.

Appreciation is extended to all FPC members for their thoughtful participation on FPC throughout the year. Special thanks goes to the Committee's departing members: Professors Rosalind H. Williams, Harriet N. Ritvo, Stephan Schrader, and Robert A. Weinberg, and Ms. Jennifer E. Carson (undergraduate student member), and Mr. Daniel J. Watt, Secretary to the Committee. Special thanks are also due to Sarah T. Campbell, former Secretary to the Committee, for her advice and assistance; to Laura B. Mersky, Administrative Assistant to the President, who helped the FPC in a multitude of ways; and to Traci A. Trotzer, incoming Secretary to the Committee, for her help with a difficult transition this spring and summer.

**COMMITTEE ON THE UNDERGRADUATE PROGRAM**

In 1992-93 following discussions among the chairs of the Faculty Policy Committee (FPC), the Committee on the Undergraduate Program (CUP), and the Committee on
Curricula (COC), a somewhat restructured set of committee responsibilities functioned in 1993-94. The CUP has the responsibility for primary oversight of the undergraduate educational program and for setting policy applied and interpreted by the COC. It reports to the FPC, which brings issues requiring faculty vote or attention to the faculty meetings. To facilitate this revised division of labor, the FPC chair almost invariably attended CUP meetings this year, and the COC chair was a frequent visitor to the CUP. The CUP chair attended COC meetings *ex officio*.

 Throughout the year the CUP exercised oversight over a large number of ongoing undergraduate educational issues and acted definitively in several instances to set new policy. In the latter category:

- The issue of cultural diversity and racial and ethnic tolerance in the undergraduate body was established as a major agenda item for the year. An on-campus retreat entitled “Education for Diversity” was organized on October 12 in order to understand the dimensions of the issue and to search for educational initiatives that might establish an improved atmosphere of tolerance for and appreciation of cultural and racial diversity. Representatives from many segments of the MIT community presented their perspectives, and members viewed portions of two films, “A Class Divided” and “It’s Intuitively Obvious.” Follow-up discussions were held at several subsequent CUP meetings. One initiative thought worth pursuing was to publish a listing of subjects that treated race and ethnic relations and cultural diversity in order to publicize to students and the outside community what was available at the Institute and to put on record the importance MIT accorded the subject of interpersonal relations in the education of its students for their future professional lives. A list was generated, which was surprisingly rich, but also indicated that much more needs to be done in the educational arena. An edited version of this list will appear in the forthcoming race relations subject guide to be published by the newly formed presidential committee on Race Relations, to which the CUP has ceded responsibility in these matters. The CUP decided, however, that a subject requirement in this area made no sense for MIT.

- An experiment had previously permitted take-home final examinations as an option to instructors teaching Humanities, Arts, and Social Sciences Distribution Requirement (HASS-D) subjects. The Committee concluded that, despite some very real pedagogical advantages for certain subjects, take-home finals implemented as a universal option presented unrealistic and unfair demands on students. A well-reasoned request from the two 6.001 instructors to permit a take-home final exam in that subject served only to confirm the potential for proliferation. The HASS-D experience had confirmed that it was difficult to regulate these demands. CUP, therefore, terminated the HASS-D take-home final experiment and proscribed future use of take-home finals.

- Consideration was given to a proposal from the Office of Undergraduate Academic Affairs (UAA) to formalize an experiment in the way freshman evaluations are conducted. The experiment, in which instructors were first solicited for input on students, who were in turn asked to respond in class (rather than the other way around) had delivered information to students and advisors in a far more timely fashion in several freshman core subjects, without noticeable loss in the quality of comments. CUP was concerned only that the new scheme provide students with an
adequate vehicle for having their specific questions convened to an instructor and answered, and CUP agreed to a full-scale experiment in 1994-95 involving all subjects in which freshmen are enrolled.

- The CUP was required by a Faculty vote setting up the HASS-D Institute requirement in 1987 to conduct a six-year review of the requirement jointly with the School of Humanities and Social Sciences (SHSS). A review committee, under the leadership of Professor Harriet N. Ritvo, Associate Dean of SHSS, met throughout the year and reported its recommendations to the CUP in April. Currently, to satisfy the requirement, students must take three subjects selected from a group of subjects assigned each year to five categories, one of which is Visual and Performing Arts. The Ritvo Committee concluded that the HASS-D plan was working well, but urged adoption of two recommendations: first, instructors in HASS-D subjects no longer be required to give final examinations; and, second, the Arts be better integrated into the HASS-D requirement, since at present students are required to distribute subject selections only among the other four categories. The CUP concurred with the Ritvo Committee's assessment of the health of the scheme and recommendation to eliminate the final examination requirement (the principal reason why the take-home final exam experiment in HASS-D subjects was implemented), but felt that the proposal for fuller incorporation of Arts subjects -- merging the Arts category with one of the category pairs for the purposes of satisfying the required distribution -- was an inappropriate vehicle. The CUP, in consultation with the SHSS, the Dean for Undergraduate Education and Student Affairs, the Dean for Architecture and Planning, and the Associate Provost for the Arts, will explore other options for fuller incorporation in the fall.

- Responding to a request by Professor J. Kim Vandiver, Director of the Edgerton Center, the CUP voted to extend Special Program status to the Center to enable it to list its undergraduate seminar subjects under its own subject designation numbers in the MIT Bulletin without having to go through a department-of-convenience for a subject number and subject approval.

- The CUP rejected a proposed experiment, emanating jointly from the UROP office and the UAA office, to let freshmen exceed the 57-unit credit limit in the spring term to enable them to include a six-unit for-credit UROP project in their academic programs. The principal fear expressed by CUP members was that many freshmen would still feel the necessity to earn money for tuition in addition to adding such a credit-bearing UROP experience beyond what was a carefully considered credit limit.

The CUP monitored a number of other on-going programs and new initiatives:

- The Committee provided a critical review of the recent Senior Survey on two occasions during its formulation and voiced serious concerns about issues of anonymity; correlation of information received with race, ethnicity, or other inappropriate distinguishing characteristics of informants; and ultimate use of the data.

- The CUP twice reviewed the progress of the new biology requirement in its three different 7.01 versions, once in each semester. Initial concerns about insulation of the faculty lecturers from students and the substantial reliance on graduate student
teaching assistants were allayed by the obvious care taken in design of the subjects and close supervision of the recitation teaching by the two very capable instructors. Concern was also expressed that, in its first year, some 200 fewer freshmen than expected were enrolled.

* The chairs of the COC and the IAP Policy Committee discussed with the CUP the use of the Independent Activities Period (IAP) for departmental-required subjects. While the faculty vote on MIT's new calendar specifically allowed a departmental-required subject of up to 12 units to be offered in one IAP, the CUP agreed that it would be unnecessarily restrictive to require such a subject in a particular year and inappropriate to require prerequisite subjects during IAP.

* The CUP reviewed the current minors program in HASS, the impact of the new science minors, a strong proposal for an interdisciplinary minor in Biomedical Engineering, and two presently less well-formulated frameworks for interdisciplinary minors in Education and in Environmental Studies.

* The shift from residence-based to freshman-seminar-based freshman advising was carefully noted, and with it the near-demise of the former. The CUP has requested that the results of a forthcoming UAA survey on the effectiveness of seminar-based advising be made available to the Committee.

* Freshman grading policy was revisited, in particular the raising of pass to a C grade and the impact on freshman failures. A proposal to adopt a graded ABC/No Record policy for the second semester was considered and tabled, pending further study.

* The CUP heard a report of the Teamworks initiative, introducing collaborative study into four freshman core subjects. The experiment was a modest success, and the CUP would like to see the concept refined and extended to other areas, such as laboratory subjects.

* Two CUP members served on the Provost's UROP Working Group and kept the CUP apprised of funding initiatives for one program about to be decimated by changes in the A-21 OMB guidelines on indirect costs.

* The CUP heard about the Writing Initiative and applauded the increasing emphasis on developing undergraduate writing skills. Members continue to be concerned about the apparent ineffectiveness of the Writing Requirement in guaranteeing an acceptable level of writing skills in our graduates.

* With the help of the Admissions Director and Dean Margaret S. Enders, the CUP explored subject utilization patterns in the freshman year, particularly the effects of advanced placement and advanced standing, deferment of core subjects to the sophomore year, and taking of upperclass subjects under Pass/No Record grading.

* Prompted by student concerns, the CUP was apprised of the current workings of the Office of Career Services and Preprofessional Advising by its Director. The Committee's view was that this office provides a critical service for undergraduate students and should be strengthened with an infusion of money and additional staff.
It was noted that preprofessional advising in most departments was at best *ad hoc*, except perhaps for departments with well-established co-op or internship programs.

- The Director of Athletics spoke with the CUP about the valuable role his department plays in the undergraduate program and student life. The CUP applauded what is widely recognized as one of the most ambitious and inclusive university athletics and recreation programs.

- Finally, the CUP looked with some depth into the phenomenon of student disaffection which is perceived to plague MIT undergraduates. Its effect on admissions was discussed with the Admissions Director, and its repercussions on alumni/ae participation and giving with the Managing Director of Alumni/ae Activities and Fund. The critical roles of R/O Week and continuing faculty/student interactions in counteracting negativism in the culture were cited.

One addition to the Committee membership was occasioned by a need for supplemental input. The CUP Chair wanted to have input from a housemaster, who would be able to report first hand to the Committee on the pulse of student life. Professor Charles Stewart III, Housemaster of McCormick Hall, was invited to serve as a voting guest member throughout the year. Professor Stewart's input proved savvy and his counsel wise, and the Chair recommended that a housemaster become a fixture in the CUP membership in future.

The Committee wishes to recognize the contributions of departing CUP members: Professors Maurice S. Fox, Leon B. Groisser and Alvin C. Kibel; undergraduate members Raajnish A. Chitaley, Anne S. Tsao, Matthew J. Turner and Brian K. Zuzga; and staff to the Committee, Marguerite E. Hoyt and Daniel J. Watt. Appreciation is extended to Dean Margaret S. Enders for her advice and generous contribution of her time to the fortnightly ancillary discussions with the Chair and CUP student members that provided student representatives a somewhat less intimidating forum for their opinions and the CUP with additional strategic information.

**OTHER FACULTY COMMITTEE REPORTS**

The Committee on Academic Performance (CAP) spent the majority of its bi-weekly meetings acting on petitions from undergraduate students requesting exceptions from various Institute rules. A total of 525 petitions were acted upon this academic year (down from 570 last year). The usual end-of-term and end-of-year meetings were held to review the performance of students making inadequate progress towards a degree and those with poor academic records.

This year the CAP initiated a review of upperclass grading policies at the Institute, focusing on the question of the possible introduction of "intermediate grades" to permit greater resolution in the assessment of student performance. The Committee members were broadly supportive of developing such a proposal next year after having solicited broad student views on the question through a survey planned for distribution during the fall of 1994. The Committee also proposed a three-year experiment (brought forward by the Undergraduate Research Opportunities Program [UROP] and Undergraduate Academic Affairs Offices in light of the increased cost of
UROP for pay) under which freshmen in good standing would be allowed to petition the CAP to allow them to exceed the second semester credit limit of 57 units by up to six units for UROP credit activity. However, the proposal was not adopted by the Committee on the Undergraduate Program.

The principal issues addressed by the Committee on Corporate Relations (CCR) during the 1993-94 academic year pertained to the changing mission of the Corporate Relations Office. Extensive discussions were held concerning the proper balance between this office’s fund-raising activities (i.e., gifts to the Institute from corporations) and its more traditional Industrial Liaison Program (ILP) role. With respect to the latter, various pertinent issues have been considered, such as helping junior faculty members establish contracts with industry, outlining success criteria for both the ILP and individual officers, and defining whether the ILP main customer is the MIT faculty or member companies. Also discussed were the reasons for recent decline in ILP membership and the relationship between the ILP and various specialized industrial consortia at MIT.

In addition, the CCR reviewed partial results of a major survey conducted by teams of Corporate Relations officers, both at MIT and in industry, aimed at ways to improve the efficiency and productivity of the Office. Finally, the Committee provided input to the recommendations of the President's Task Force on Industrial Linkages.

The Committee on Curricula (COC) met eight times during the 1993-94 academic year. In addition to its usual functions of reviewing proposals for new, altered, and cancelled subjects and hearing student petitions for variances from General Institute Requirements, the COC addressed a number of substantive curricular, programmatic, and policy issues.

The salient actions taken include approval of: minors in Nuclear Engineering and in Linguistics; major departures (S.B. in Humanities) in Film and Media Studies and in East Asian Studies; curricular changes to the 21A (Anthropology/Archaeology) degree program, including the fact that a thesis will no longer be required; a new Physics curriculum proposed for the 1995-96 academic year which incorporates curricular changes suggested by the Physics Visiting Committee to correct present deficiencies in academic subjects covering contemporary applications of quantum mechanics; and cancellation of Russian and dance subjects because of the elimination of these programs due to budgetary constraints.

Among the topics discussed were: the COC's duty to ensure that IAP-only subjects satisfy basic educational guidelines and follow the Faculty Regulations for departmental programs; a subject cancellation policy in which approval is granted when the cancellation is due to curricular, budgetary, or personnel reasons and does not involve a core subject in a given field or leave a curricular gap; and, finally, interdepartmental minors which arose with the proposal to establish a minor in Biomedical Engineering. The issues surrounding this proposal (the number of required subjects and the fact that it might not be readily accessible to everyone and may not remain viable after a change of major) will constitute a principal focus of discussion for the COC during the fall of 1994.
The Committee on Discipline (COD) held ten hearings this year. The charges included theft, sexual harassment, altering financial aid forms, altering a grade report, cheating on examinations, and plagiarizing a thesis. Disciplinary sanctions issued by the Committee ranged from formal probation through expulsion. One case is pending until an outside investigation is completed. The COD expects to hear at least two additional cases during the summer of 1994.

The Committee also reviewed a number of petitions for re-admission to the Institute and for removal of disciplinary notations from transcripts.

In conjunction with the Dean for Undergraduate Education and Student Affairs, the COD intends to report on disciplinary actions regularly at Faculty Meetings. The Committee expects that this will sensitize faculty to the need for more consistent reporting of incidents to the COD or to the Dean’s Office, and to make students more aware of the risks taken when engaging in dishonest behavior.

The Harold E. Edgerton Award Selection Committee issued a call for nominations that was distributed by direct mail to all faculty and published in Tech Talk. Follow-up letters were sent to heads of departments to solicit further nominations. Eleven nominations were received, reviewed, and debated. Professor Martha L. Gray of the Department of Electrical Engineering and Computer Science (EECS) and of the Harvard-MIT Division of Health Sciences and Technology (HST) was selected as the 1994 awardee. The Committee citation presented at the April Faculty Meeting cited Professor Gray’s significant contributions to the understanding of how the growth and metabolism of living musculo-skeletal tissue is influenced by physical, chemical, and mechanical factors. Her landmark work using nuclear magnetic resonance has been used to detect changes in cartilage. Professor Gray is a member of an unusually large number of Committees in both EECS and HST and won the Joel Spira Teaching Award in 1992.

The Committee on Faculty-Administration (CFA) focused on issues related to the end of mandatory faculty retirement which took effect in January 1994. In particular, the Committee reviewed several proposed changes to the MIT Retirement Plan. As part of this process, the CFA spent a significant amount of time becoming educated on the structure of the Plan and met with senior and mid-career faculty.

It was the opinion of the Committee that the current plan is quite generous in its provisions, but is limited in its distribution options. The CFA believed that in creating new distribution options, the Plan should not be changed in ways that would provide disincentives for faculty retirement.

Over the next year, the Committee will continue to review the Retirement Plan and other factors which influence individual faculty decisions on faculty retirement.

The James R. Killian, Jr. Faculty Achievement Award Selection Committee convened for four meetings in the process of selecting this year’s awardee, John H. Harbison, Class of 1949 Professor of Music. Bringing this spotlight of recognition to a distinguished member of the arts faculty for the first time was especially satisfying in view of Dr. Killian’s early characterization of MIT as “a university polarized around science, technology, and the arts.” A total of 19 nominations were considered this
year, of which seven were newly submitted, five were renewals of previous nominations, and seven were nominations carried over from last year. Of these, seven were considered to be particularly promising, and additional information was requested for the final round of consideration. Professor Harbison’s nomination quickly bubbled to the top, and his award was announced at the April 20 Faculty Meeting. Because of the considerable community effort that goes into preparing Killian Award nominations, we have elected to forward eight of the nominations to next year’s committee so as to avoid undue duplication of that effort. Since next year’s chairman is also a member of the present committee, he will be providing valuable continuity in the deliberations of this happy but inherently difficult selection process.

The Committee on the Library System (CLS) met four times. The year began with an address by the Provost concerning budget reform at MIT, and with reports by the Director and Associate Director of Libraries concerning the library’s budget cuts and imminent plans for a new, automated operating system.

During the remaining meetings, the CLS discussed the operating procedures of several components of the library and the concerns of our three student members. These concerns were addressed in two preparatory meetings and two full meetings, while queries concerning procedures dominated three meetings. Each began with informative presentations by library staff members: four responsible for selecting materials in their own subject areas, two concerned with Inter-Library Loan, one leader of automation strategies/systems, one involved with copyright ownership issues, and the head of Institute Archives and Special Collections. The Committee was thus kept abreast of procedures and concerns, and by means of discussions, it pondered possible changes in the system.

At the April Faculty Meeting, the Committee on Nominations presented the names of 36 faculty members to serve on 14 standing committees of the Faculty and one to serve as Chair-Elect. The Faculty voted to approve the full list at the May meeting. The Committee is happy to report that 85 percent of the candidates initially approached agreed to serve.

The Committee on Outside Professional Activities (COPA) helped six members of the faculty and administration avoid or resolve conflicts of interest. The issue arising most often was involvement of students or staff in outside activities of a faculty member. Existing policies and procedures seem to be working.

The Committee on Student Affairs (CSA) was inactive during the 1992-93 academic year and during the first semester of the current academic year. During the second semester, the CSA held six meetings and addressed two major issues: housing and dining. The Committee heard testimony from several sources, including Arthur C. Smith, Dean for Undergraduate Education and Student Affairs; Samuel Jay Keyser, Associate Provost for Institute Life; O. Robert Simha, Director of Planning; William L. Porter, Housemaster of Burton-Conner; Edward V. Cogliano, ARA Food Service employee; Albert L. Hsu, Chair, Baker Housing Dining Committee; Sara Maziwulewicz, Alpha Phi; Prashant B. Doshi, President, Interfraternity Council; and Rajiv K. Sheel, graduate student. Some CSA members also visited Senior House and East Campus.
In the domain of housing, students and faculty are concerned about crowding, cleanliness, and the old and dysfunctional physical plant. In the domain of dining, their concerns include lack of variety in the menus, scarcity of “healthy foods” and vegetarian meals, hot meals served at room temperature, and limited dining times. In the fall, the CSA will continue its efforts to help improve living and dining conditions for students by meeting with members of the Department of Housing and Food Services and by making specific recommendations.

The Committee on Undergraduate Admissions and Financial Aid (CUAFA) had a number of new members and spent the early part of the year reviewing current policies, practices, and statistics on admissions and financial aid in preparation for considering the recommendations made by a special committee appointed by the President to consider admissions and financial aid policies for international students. Some adjustments to these policies were made, but the expected number and diversity of the undergraduate international student population will not change significantly.

The Committee also reviewed the new admissions publications. The view book, although somewhat controversial, won several awards and seems to have been quite effective at getting the attention of prospective students. It was targeted at overcoming the misperception that the MIT education is limited to science and engineering. It was intended to attract students who dismiss MIT as not being broad enough.

The year was topped off by the news that the fall 1994 freshmen class will include 40 percent women.

During the 1993-94 academic year, the Committee on the Writing Requirement continued to be active in carrying out its charge from the faculty to oversee the undergraduate writing requirement and to foster instruction in clear, effective writing throughout the undergraduate curriculum. The Committee is currently conducting its second review of departmental Phase Two plans and grading standards and is also developing a new handbook for departmental Phase Two coordinators and administrators.

The Committee actively encouraged the new Writing Initiative, jointly sponsored by the School of Engineering and the School of Humanities and Social Science, as well as a new project by Undergraduate Academic Affairs to increase the amount of writing required of students in all undergraduate subjects.

Responding to a request from the School of Humanities and Social Sciences, the Committee modified the procedure by which students submit Phase One papers. The Committee also modified the procedure by which students can complete Phase One through participation in Project Interphase.

To alleviate over-enrollment in Phase One writing subjects and to provide a greater opportunity for freshmen to take an introductory writing subject during their first year at the Institute, the Committee and the Program in Writing and Humanistic
Studies have agreed that, beginning with the fall 1994 term, upperclass students will no longer be given priority in these subjects.

Sincere appreciation is extended to the following faculty members for their special contributions and service as appointed Chairs of the Standing and Special Faculty Committees during the past year: Nigel H. M. Wilson (Academic Performance), Alexander M. Klibanov (Corporate Relations), Suzanne Flynn (Curricula), Triantaphyllos R. Akylas (Discipline), R. John Hansman (Faculty-Administration), Lowell E. Lindgren (Library System), Claude R. Canizares (Nominations), Charles C. Counselman III (Outside Professional Activities), Suzanne H. Corkin (Student Affairs), J. Kim Vandiver (Undergraduate Admissions and Financial Aid), Kip V. Hodges (Writing Requirement), (Edgerton Award Selection), and Stephen A. Benton (Killian Award).

ROBERT L. JAFFE
SARAH T. CAMPBELL
TRACI A. TROTZER
Once again this year, concern for the safety of those who work, study, and reside on the MIT campus was a high priority. New campus lighting along Memorial Drive and in Killian Court was installed for improved visibility, card readers were put in place at the Westgate and Vassar Street parking areas for tighter access control, major safety and security-related improvements to the Albany Street Garage (N4) were initiated, and card access control replaced exterior door key control in most of our dormitories.

During the year, many renovations and physical improvements were undertaken across the campus. Construction began on the Tang Management Center project and the Cambridge City Council granted permission to construct a pedestrian bridge over Ames Street which will connect the Tang Center, when completed, with the Muckley Building (E40). Construction continued on the Cogenation Project with completion projected for late next winter. Major renovation projects were initiated in Building 3, the Pappalardo Mechanical Engineering Laboratory; Buildings 3, 5, 7, and 10; Architecture; W2/W2A, conversion to dormitory spaces; W11, the Religious Center; and the E17 Animal Facility.

Two projects were completed this year, the Biology Building (68) and the CASPAR (Cambridge and Somerville Program for Alcoholism and Drug Abuse Rehabilitation) Emergency Service Center at 240 Albany Street. The Biology Building, a 247,250 ft.² facility, is a state-of-the-art biology building with office space, conference rooms, laboratories, and animal facilities. Ground was broken for the CASPAR Center, a 55-bed rehabilitation facility, in October and, despite difficult winter weather conditions, it was completed and occupied in the late spring.

The Institute purchased 478 Commonwealth Avenue for the purpose of providing a chapter house for the MIT Chapter of Alpha Chi Omega Sorority. Renovation commenced immediately upon the closing of the sale with occupancy anticipated for the start of school in the fall.

Implementation of a campus-wide student and employee electronic identification card came closer to completion. Student and employee color picture ID cards were produced at the Card office and meetings were held during the year to establish guidelines and policies for use of the card.

During the academic year, the Publication Services Review Group completed their review of the publications process on campus. The group made several recommendations, which are pending an evaluation of how they might be incorporated into the subsequent Institute reengineering initiative. In the interim, a follow-on initiative was begun which was designed to further the understanding of the digital publishing environment.

A group of individuals, all of whom are involved with the implementation of services in support of persons with disabilities, was called together in order to better coordinate the Institute's response to the Americans with Disabilities Act (ADA) and other related issues.

Affirmative Action efforts continued throughout the year. We are pleased to note that an Hispanic female was hired in the support staff category of Housing & Food Services and an Asian male was hired as an administrative staff member in the Physical Plant. These additions will improve our efforts aimed at having a more diverse workforce and help us toward fulfilling our goal of increasing the representation of Hispanic and Asian employees. As for our efforts to promote women in non-traditional areas, we are pleased to report that the Assistant Supervisor of the Grounds Department has been promoted and her responsibilities have increased to include waste management and project coordination.

Following are individual department reports.

WILLIAM R. DICKSON
In keeping with the mission of the department, throughout the year the Campus Activities Complex (CAC) provided event planning, support, and supervision for over 9,000 events with a combined attendance of approximately 600,000 people. The Stratton Student Center alone served approximately 90,000 people in an average week of operation. Major Institute events supported by the department included the dedication of the Edgerton Center, the ground breaking and dedication of the CASPAR, the World Economic Forum, and the 1994 Commencement and Technology Day ceremonies.

This year, efforts continued to maintain quality conditions in CAC-managed facilities. Individual staff have been assigned to buildings to ensure that cleaning, maintenance, and usage issues were addressed and promptly resolved. Several spaces within W20 underwent renovations during the year. The new fifth floor copy center was constructed and retail space was renovated to house the new MIT PC Service Center. Major construction and renovation was conducted at the Religious Activities Center (W11) to house the MIT chaplains, Hillel Center, the Muslim Prayer Room, and student religious activities groups. Efforts continued to address the Americans with Disabilities Act mandated barrier removals, as well as improving the level of support provided for the disabled at scheduled events.

Reviews of the finances and operations of several social and educational programs were conducted during the year. A revised business plan and renewed emphasis on marketing strengthened the financial position of the Student Center Committee 24-Hour Coffeehouse. The Leadership Education and Development (LEAD) program, sponsored jointly with Undergraduate Education and Student Affairs, introduced a Freshmen Seminar this year. The Senior Gift of the Class of 1994 is the renovation of the Information Desk in W20. The class members have committed over $30,000 in pledges for the integrated Information Resource Program and Ticket Office, which will be known as The Source.

The Stratton Student Center vending program enjoyed continued success with revenues, exceeding those of the previous year, providing support for the programming efforts of the department and equipment upgrades for the renovation of the Information Desk. The real estate portfolio of the Stratton Center maintained full occupancy during the year and lease options were renewed with eligible tenants.

PHILLIP J. WALSH
Throughout the year, the MIT Campus Police continued to serve the MIT community with 24 hour professional police and emergency medical services. There were a total of 1,970 complaints (situations which required the recording of an incident by a police report) recorded this year. Of these complaints, 17 were in the crimes against persons category. The Campus Police made 88 arrests on MIT property during the year. The most serious charge was assault and battery by means of a dangerous weapon, while the most common charge was trespassing.

Larceny again continued to be the largest category of crime with which the Institute had to contend this year. The total number of reported incidents of larceny of Institute property was 183, a 55 percent increase when compared with last year. Computers and computer components were, once again, the most frequent type of Institute-owned property stolen. The number of residence hall losses was up 19 percent from last year, with a total of 125 reported thefts. Motor vehicle and bicycle thefts also increased slightly this year with a total of 61 vehicles and 158 bicycles stolen.

This year, emergency medical service transports totaled 2,089. Of these, 319 were classified as emergencies.

The Campus Police safety shuttled service, A Safe Ride, provided 121,253 personal safety escorts during the year.

The MIT Campus Police Department looks forward to continuing to provide the community with professional police and emergency medical services in the coming year.

ANNE P. GLAVIN
Progress continued toward the sale of the adjoining Stearns' estate, willed to MIT in 1981 by neighbor Russell B. Stearns. Negotiations are currently underway between an interested buyer and MIT concerning price, land use restrictions, and other specifics relating to the property and a sale appears imminent. Once sold, the proceeds will be used to set up an endowment whose funds will be utilized to assist the Endicott House in its major capital projects.

The Sloan School of Management's Program for Senior Executives continues to undergo changes which are certain to affect Endicott House. The Senior Executive Program, which has been held at Endicott House each spring and fall for the past 38 years, has suffered decreasing attendance, particularly in the spring session, the last several years. Discussions were held to determine if it was feasible to continue with the spring session and a final decision will be rendered in the spring of 1995. Discontinuation of this session would have a major financial impact for the House.

As a result in the decrease of both general business and the Senior Executive Program, steps were taken to increase business from other sources. A new Director of Conference Sales was hired, a new conference planner/brochure was produced, and efforts are underway to target prospective clients as well as maintain past users of the facilities.

Several capital improvements were completed during the year to keep Endicott House competitive with other facilities. In order to accommodate summer business, proposals were obtained to air condition the small dining room. The project was awarded and completion is expected early next year. In addition, seven bedrooms in the main house were outfitted with new slim-line window air conditioning units. A central system was considered but deemed unacceptable due to the high costs involved. Finally, a study was conducted to expand the existing parking lot. Prices for various schemes are now being submitted.

From a statistical standpoint, there were 52 overnight conferences held at the facility, lasting from one night to the eight-week Sloan School Senior Executive Program. Of the total, MIT accounted for 27 of these residential groups, six were from other non-profits, and the remaining 19 represented corporate businesses and some educational groups not classified as non-profits. There were 4,387 room-nights occupied by a total of 4,603 guests this year compared with 4,540 room-nights occupied by 4,923 last year.

HOWARD F. MILLER
This year, total income for all Graphic Arts services was $6.1 million, the same as last year. The distribution of that income among the various Graphic Arts' departments was also virtually unchanged from last year.

Computerized pre-press technology was introduced. Most of the work Graphic Arts typesets is now output as negative film directly from the Linotronic Imagesetter. The addition of color throughout the digital production systems continues. This year, the typesetting department began to offer a color presentation slide service for charts, graphs, texts, or other graphics. Customers can either create the material on their own computers or have Graphic Arts do the preparation in addition to the transfer to slides.

The Student ID/Picture program was transferred to Housing and Food Services this year as part of the MIT ID Card program.

Several improvements to the Graphic Arts computer network are providing increased services to other parts of the Institute. The billing system has been expanded to include the work done in the copy centers. This will allow charges from the copy centers to appear on monthly statements along with charges from work done at the main Graphic Arts facility at Building N42. In addition, we now upload billing data directly to the General Ledger through the Journal Voucher System.

The Student Center copy center was closed and those operations were moved to the 11-004 copy center. The E52-045 copy center expanded their hours and will remain open one hour longer, closing at 6:00 p.m.

Albert K. Paone retired after 39 years of service with Graphic Arts. He began as a Photographer and subsequently served as Assistant Director, Associate Director, and Acting Director.

VERNON A. RAINE
This year, after several years of negotiations, a retail plan for MIT contract food services was agreed upon. Food Services will now operate on a unit break-even or better basis. The Institute will, therefore, no longer be called upon to subsidize direct cost deficits and will net 60 percent of all income achieved over direct costs. Elimination of direct cost subsidies will result in a meaningful financial benefit for the Institute in that a decade or more of direct cost losses will finally be brought under contractual control.

Throughout the year, technology and communications systems were developed and existing systems were improved. The House Managers and housing staff developed E-Mail networks such as the Nightwatch Manager Network which will enhance 24-hour security and operating communications. An electronic communications system was also further developed which lists available student housing space. The student room reservation process and house fact book were also completed and will be produced next year. The Housing Office also assisted Information Systems in implementing the RESNET system, which will offer approximately 2,800 students individual computer communication and information access directly from their own rooms.

Student security remained a quintessential priority in the Housing Department again this year. As a result of the new MIT Student ID Card program, ten houses were equipped with electronic card readers to strengthen the 24-hour locked student dormitory initiative. The Westgate Parking Lot was also equipped with a card reader to monitor access control. In addition, a new vehicle was purchased to enhance 24-hour security visibility and improve student customer service response.

During the year, implementation of a campus-wide student and employee electronic identification card came closer to fruition. An informal consortium was arranged with the Harvard ID office to share information. Employee color picture ID cards were produced at the Card office on demand and meetings were held during the year to establish guidelines and policies for use of the card.

LAWRENCE E. MAGUIRE
The Office of Insurance and Legal Affairs, joining with the rest of the Institute, was gratified by the favorable settlement this year of the Overlap Antitrust Litigation. The office is now pursuing the insurance carrier for reimbursement of legal fees related to that defense. It is unclear at this time how much of the total amount will be recovered. During the year, $450,000 was recovered for legal costs in the defense of a matter that was settled the previous year.

In a separate case, filed by a former MIT graduate student alleging he failed to receive due process in the proceedings administered by MIT's Committee on Discipline, judgment was in MIT's favor, affirming that the Committee on Discipline did exercise due process in this case. This finally came to trial after nine years on the docket.

During the year, significant progress was made toward settlement of MIT's involvement in two hazardous waste sites. The ultimate cost to the Institute (principally due to waste disposal from Lincoln Laboratory), is somewhat uncertain, but will probably be in the range of $300,000 to $500,000 for one of the sites.

Under MIT's self-insured general liability program, through the Barton Insurance Company, Ltd., $250,000 was paid out in claims settlement. Although this figure represents an increase over last year, this is largely attributed to several lengthy court proceedings for claims dating as far back as 1989, which were settled this year. Based on outstanding liability claims, the level of settlements next year should decline, bringing paid losses down to a more favorable level for the self-insured program. This year's total cost for all liability insurance was approximately $1.4 million. Due to MIT's favorable loss history, most policies renewed at the expiring rates.

The Institute's self-insured workers' compensation program absorbed some significant losses during the past fiscal year, with settlements in excess of $400,000 (for several difficult and potentially long-lasting claims). With these settlements, the workers' compensation losses should return to acceptable levels. The continued diligence of MIT's Safety Office in monitoring the MIT workplace, administering the program, and coordinating its efforts with the Insurance Office in managing and settling claims will continue to be vital to the success of MIT's self-insured program.

The number of property claims processed by this office last year was 87. Of these claims, many fell under the deductible, resulting in a higher payment by MIT, approximately $200,000, than reimbursements to MIT from Kemper, MIT's property insurer, of $110,000. MIT's property insurance program was renewed during the year for approximately $550,00 with the total insured value in excess of $1.8 billion. The commercial automobile and aircraft insurance premiums for the year were $250,000 for a fleet of 224 vehicles and nine aircraft. Twenty claims for property damage to rental and leased vehicles were processed this year for a total claims cost of $22,000.

As in prior years, more than 100 students requested legal guidance involving a broad range of legal questions.

THOMAS R. HENNEBERRY
This year, with the availability of continuous feed bubble jet printer technology, the Space Accounting group met a long-standing goal of producing the first complete edition of MIT "bookplans" based on electronic floorplan files. The group also enhanced its distribution of electronic floorplans with a well-received series of training materials and classes for PC and Mac users of CADVIEW™, a read-only floorplan querying system. The federal auditors pronounced the INSITE-CAD™ floorplans and INSITE™ space inventory the best space inventory operation that they had seen and that they were advising other universities to emulate this process.

During the year, the OFMS Systems Development group successfully moved MIT's production INSITE™ database from a VAX VMS environment to a Sun UNIX environment. This move will facilitate future integration with other MIT space-related data and future development of client interfaces to INSITE™. The team also developed a PC-based interface that allows members of the MIT community to view INSITE™ space data. This interface is currently being used by the Physical Plant space analyst. In addition, the graphics team began the design effort for a new INSITE-CAD™ system that will incorporate multi-media data and additional space allocation and planning functionality for MIT's 822 floorplans currently being maintained.

Technology sharing with other universities and hospitals continued to be accomplished this year through the OFMS Consortium group. The team has also been heavily involved in the implementation of the new workstation INSITE™ system. The group has developed and published all documentation including reference, presentation, and training materials and the first formal training course in the new INSITE™ was conducted for representatives from five outside organizations using this MIT-developed system.

Throughout the year, the office continued to produce several facilities management industry courses and an internationally recognized conference for senior facilities executives.

KREON L. CYROS
This year, under new leadership, the department has embarked on a major strategic planning effort which encompasses both an internal and external review. This initiative includes a new customer service/community awareness program which has included meetings with and surveys of members of the MIT community. The ultimate goal is to achieve a higher level of efficiency and service.

ENVIRONMENTAL RESPONSIBILITIES
During the year, added responsibilities for developing and ensuring environmental compliance in a number of areas were assumed by Physical Plant. A full time staff person was designated to closely oversee paper and aluminum recycling as well as to ensure compliance with environmental rules and regulations that fall within the Plant’s areas of responsibility. Waste management and water and energy conservation continue to be major objectives within the Plant.

ADA PATH OF TRAVEL REQUIREMENTS
A major effort is underway to bring the 150 elevators on campus in compliance with the 1996 Elevator Code and the Americans with Disabilities Act (ADA). Path of travel requirements dictated many changes throughout the main and east campuses. In addition, renovations to Buildings 50 (Walker), W16 (Kresge), and W15 (Chapel) are presently under design in order to meet ADA requirements.

MANAGEMENT INFORMATION SYSTEMS
Throughout the year, efforts continued to develop the Physical Plant job costing information system. The labor module was completed and the utility distribution and accounting modules are under development. Cross-platform systems were developed to enable PC and Macintosh users in the Design and Construction Services Group to track summary project information and cost data. CAD viewing and plotting capabilities were added in the Engineering, Utilities, Design and Construction, and Mechanical Operations Groups through the expansion of the drawing management file.

CONFINED SPACE TRAINING
Over 175 individuals were successfully trained for working in confined spaces. MIT is one of the few institutions in the region to complete a written program and have a fully trained and equipped in-house rescue team.

OPERATIONS

Electric Services
A major upgrade of the fire alarm systems within the main group was completed during the year.

Substantial lighting improvements were also put in place creating a brighter, safer campus. In Killian Court, several original Bosworth lighting fixtures were re-installed for added security.

In Eastgate (E55), a newly installed elevator control system has made an enormous improvement to the elevator service in this high-rise residence.

Preventive Maintenance (PM)
In order to update PM records and Lockout/Tagout procedures, a comprehensive survey of equipment is underway. Eight buildings have been completed to date.

Building Maintenance
This year approximately 11,000 projects were completed. One project that stands out was the preparatory work for the World Economic Forum which was held on campus in September. This
project required a tremendous amount of dedication, team work, and effort to ready the Institute for an event of this magnitude.

**Grounds Services**
Campus landscaping and garden upgrading continued throughout the year including additional use of low maintenance shrubs and ground cover. This winter, the Grounds Department had to contend with the heaviest overall snow amount ever recorded in this area. With the installation of three new irrigation systems, adjacent to Tang Hall, the Student Center, and Building 1, the campus irrigation effort is now approximately 85 percent complete.

**UTILITIES GROUP**
Construction continued on the Cogeneration Project. Foundations for the new generating equipment and the building addition were completed, a new control room was constructed, re-instrumentation of the existing chillers and boilers was completed, new 13.8 and 2.4 Kv substations were installed, and reconfiguration of Substation #1 was completed. Upon completion of the Cogeneration Project, the Institute will essentially have a 100 percent power backup which should ensure reliable campus power.

The Northeast Utility Corridor Project was completed during the year.

In order to satisfy government audit requirements for utility cost accounting, a major effort was undertaken to install additional steam and chilled water meters throughout the main campus. Installation of these meters, along with a recently completed utility weighting study, will permit us to justify an appropriate level of indirect cost recovery.

**SYSTEMS ENGINEERING GROUP**
The Systems Engineering Group, which was initially formed in December, provides building systems engineering leadership to meet needs for the long-term benefit of the Institute. Long-term objectives include maintaining a firm position in utility conservation and developing funding mechanisms to support infrastructure renewal.

**DESIGN AND CONSTRUCTION**

**Building 68 (The Biology Building)**
Building 68 is fully occupied and operational. This 247,250 ft.\(^2\) modern biology building contains office space, conference rooms, laboratories, and animal facilities. A bridge connects the building with the Landau Building (66) and tunnels connect it to both the Seeley Mudd Building (E17) and the Landau Building (66). In that the tunnel to the Seeley Mudd Building crosses under Ames Street, the MIT community can now walk from anywhere in the main group to the Whitaker College (E25) and the medical facilities (E23) on the East Campus without going outside.

**Renovations and Additions**
Renovations and additions that will enhance learning and working conditions for the community are underway at Buildings E51 (Tang Center), W2/W2A, Buildings 3, 5, 7, and 10 (School of Architecture), 16 and 56, 3 (Pappalardo Mechanical Engineering Laboratory), W11 (Religious Center), and E17 (Animal Facility). In addition, 87 smaller space management projects were designed and completed this year consisting of office, classroom, and laboratory renovations.

**VICTORIA V. SIRIANI**
Planning efforts at MIT this year have been stimulated by financial constraints, new intellectual opportunities, and the desire to share the Institute's plans with the broader community. These events have served to emphasize the need for timely and creative planning. During the year there have been major strides in our institutional, physical, transportation, and community planning activities that will have a significant affect on the future operations of the Institute.

CAMPUS PLANNING
This year, institutional research, policy analysis, and planning have focused on making improvements in the availability of five-year plan data for senior officers' budgetary reviews, providing a central source for data on MIT, enabling MIT to respond with accurate and consistent data to over 90 survey requests from the NSF to U.S. News and World Report's annual ranking of the best universities to a survey of universities' mail systems. The statistical profiles of academic departments have been used extensively by departments for their own planning and for use with visiting committees reviewing departments' activities.

In addition, highly reliable data of consistent quality is now regularly and easily exchanged with peer institutions as well as national agencies such as NIH and NSF for use in institutional needs analyses. Increasingly, MIT's Washington office has been using the data resources that have been created for use in legislative briefings.

Two key studies completed this year should assist in providing better information for decision-making. The first was an enrollment, housing, and budget model which will help determine what MIT's enrollment targets should be based upon for our available housing resources and projected financial plan. The second is a careful analysis of options available to MIT for introducing new arrangements for allocating and paying for parking on the campus.

Major accomplishments this year included the completion of the Land Resources Plan providing for more accurate and reliable information on the Institute's current land resources and future land resource requirements. This document now provides the basis for calculating MIT's payment in-lieu-of taxes to the City of Cambridge and other cities and towns in which MIT owns academic property.

ACADEMIC FACILITIES PLANNING
Academic Facilities planning this year included the development of a facilities plan for the re-occupancy of Buildings 16 and 56 following on from the relocation of the Biology Department to its new building (68).

Project 2000, the Classroom Renovation Program, moved into its fourth year. Planning for the Tang Management Center continued through this year with the completion of design and the agreement of the Cambridge City Council to permit construction of a bridge connecting the new Tang Center and the Muckley Building (E40) over Amherst Street. This brings the goal of an interconnected campus one step closer to fruition. Planning assistance was also provided for numerous other projects. Reports were prepared on the re-use options for building W59 following the relocation of the Grounds Department to a new facility at 310 Massachusetts Avenue and the future renovation of classrooms in E51 following completion of the Tang Center. Planning also went forward for the School of Engineering's AI/LCS project.

Planning for housing and student support facilities focused on the preparation for a review of MIT's Housing Master Plan, the conversion of Buildings W2 and 2A to new women's dormitory facilities associated with McCormick Hall, and the conversion of Building W11 into a new home for religious counselors and additional private dining room and meeting space. Further implementing the plan to
expand independent housing for women, a building to house a new sorority (Alpha Chi Omega) at 478 Commonwealth Avenue was acquired. This will provide accommodations for an additional 25 women students.

Planning for athletic facilities this year included the preparation of a master plan for Briggs Field, the expansion of women's facilities in the Pierce Boathouse, and the development of a presentation for the Athletic Department's visiting committee on the history and development needs of MIT's athletic program.

Landscape planning and development this year featured the completion and dedication of the Carleton Street Plaza, providing for a handsome new entrance to the Campus from Kendall Square; street lighting on Memorial Drive; and renovation and lighting of the Killian Court. Landscape planning went forward for the Biology Building along Ames Street, the Tang Center along Amherst Street, and the CASPAR site on Albany Street. New parking lots on Vassar Street, Albany Street, and Sydney Street were under planning or development this year and studies for the landscaping of the Building 3 Courtyard were prepared in anticipation of developments in that area.

Transportation parking and circulation planning required major efforts this year. The City's Parking Freeze Ordinance required that MIT document for City approval an historical inventory going back 25 years of MIT's 4,000 parking spaces. This difficult and painstaking job was completed and the City's Parking Commission certified the use of our parking resources. We continued our work in improving the utilization of our parking facilities through the equitable allocation of our parking resources based on the Transportation and Parking Committee's policies. We, along with other employers in the City of Cambridge, are subject to pressures under the Environmental Protection Act to reduce our dependence on private automobiles as a major source of transportation for our employees.

After many years of MIT and community efforts, the MBTA has agreed to begin to provide circumferential transit service connecting Boston, Brookline, and Cambridge. This new service will begin in the fall of 1994 and will provide service to the campus initially along Vassar Street.

As part of MIT's responsibilities as a major employer under the Clean Air Act, the Institute has begun the process of preparing a Transportation Management Plan. This plan will propose alternate means of transportation for MIT's residents and employees. One of the key elements of this effort has been a fresh look at fees for parking on the MIT campus. The results of this effort have been submitted to the Institute's administration for consideration.

Work has begun on the campus-wide barrier removal plan, a key part of meeting obligations under the Americans with Disabilities Act (ADA). As a result of MIT's acquisition of certain streets in and around the campus as a part of the CASPAR agreement, a new street signage system has been designed and will shortly be installed on campus streets. A Campus Bicycle Report was completed and submitted. One of its recommendations, the provision of new-style bicycle racks, has been implemented across the campus. Work continued on the Massachusetts Avenue-Memorial Drive intersection in cooperation with the Metropolitan District Commission and the City of Cambridge.

The highlight of community planning activities this year featured a major presentation of MIT's plans to the Cambridge community. This presentation was presented at several public forums and converted to video for further dissemination. It presented to the general community a review of MIT's history in Cambridge, the planning issues which face MIT, and institutional hopes for the future.

Kendall Square was the focus of a forum stimulated by the Mayor of Cambridge to look at ways in which this important part of MIT's neighborhood could be improved with respect to its qualities and its
character. MIT presented its vision for what this part of our community could be like and elements of these ideas have been embodied in the City Planning Board’s recommendations.

Community activities this year included the planning for a new public park at 82 Pacific Street on land MIT will make available to the community. Efforts to upgrade Central Square, the continued discussion of the city’s Growth Policy statements, the development of a new report on payments in-lieu-of taxes for all of the communities in which MIT is a land owner, and a number of public improvements on City streets surrounding the campus that will help the general quality of the environment. Finally, MIT fulfilled one of the commitments to Cambridgeport with the completion of the conversion of 640 Memorial Drive for a new commercial tax paying activity.

O. ROBERT SIMHA
WORKERS' COMPENSATION
This year, Massachusetts became the first state to require utilization review for all open Workers' Compensation cases. Utilization review is a system for monitoring the appropriate and efficient allocation of hospital, medical, or other health care services received by employees who have been injured on the job.

The number of industrial accidents remained similar to the number in recent years but there appears to be a shift in the populations of those being injured. Repetitive strain injuries (RSI) have significantly increased injuries to the exempt/administrative staff while injuries to the hourly/service staff appear to be decreasing.

EDUCATION AND TRAINING
Training of Physical Plant workers on new OSHA standards, appropriate Lockout/Tagout procedures, electrical safety-related work practices, and safe confined space entry techniques significantly increased this year.

A new internal procedure for cutting and welding operations was developed and implemented at the request of the Cambridge Fire Department. Over 50 people were trained as authorized cutting and welding supervisors. In addition, material handling seminars aimed at preventing back injuries were provided for members of Lab Supplies, Physical Plant, and the Center for Advanced Engineering Studies.

Safety Office staff participated in a hazardous materials training seminar sponsored by the Cambridge Fire Department.

HAZARDOUS MATERIALS
As the completion of the Biology Building neared, professional hazardous waste vendors were hired to dispose of and move chemicals during the relocation of the new tenants to the building from Buildings 16, 56, and E25. This greatly reduced the potential for hazardous material spills and exposure of MIT personnel to chemicals during the move.

During the year, the Institute entered into a memorandum of understanding with the Cambridge Fire Department which established protocols for both MIT and the Fire Department in responding to hazardous material incidents.

FIRE PROTECTION
The high rise sprinkler program continues with installation of sprinklers in Buildings 36 and 38. Physical Plant began to assume responsibility for this program during the year with the Safety Office providing oversight.

Fire alarm acceptance tests were completed in Buildings 68, W11, and E23 and a program for replacement of fire alarm systems in our housing inventory was initiated.

During the year, there were two laboratory fires, one each in Buildings 18 and 54, which caused significant property damage.

SAFETY AUDITS
A number of major project reviews were conducted during the year including the Plasma Fusion Center's Mark II Furnace, Physical Plant's Co-generation Plant, and the new Biology Building (68).
OSHA investigated a toxic gas response alarm complaint in Building 13. As a result, an existing Standard Operating Procedure (SOP), was clarified.

NEW INITIATIVES
A review of the safety performance of Institute-owned vehicles that was conducted by Liberty Mutual in conjunction with the Safety Office indicated that sufficient levels of operator training are currently being achieved.

The Institute's RSI Program Committee published revised documents which focused on prevention and proper medical care.

Much work was accomplished with regard to emergency responses. The emergency response group (ERG) procedures were updated. The Cambridge local Emergency Planning Committee initiated and practiced a mass evacuation plan in which the Safety Office, Environmental Medical Service, and Physical Plant participated.

JOHN M. FRESINA
Although the chance to pay tribute to Constantine B. Simonides is one that I gladly would have welcomed while he was alive, it is with a profound sense of loss that I now write these words to honor him. But perhaps it is especially fitting that the section of the Reports to the President in which Constantine, as Vice President and Secretary of the Corporation, would have reflected on the past, looked to the future, and praised his staff, is instead a place to reflect on his enormous influence on MIT, and a chance to celebrate an extraordinary life.

To list Constantine's specific accomplishments over the years might reveal the range of his responsibilities at MIT, but even a detailed account would not tell the real truth about him. I think his most important and most recognizable role was simply that of Constantine, the person. It was his qualities as a human being that set him apart. In these past months, during which many of us have met and have found some comfort in telling “Constantine stories,” what is remarkable is the consistency of the qualities that emerge from these stories.

Constantine’s endless curiosity was legendary, but it stemmed from a deep-rooted need to know, to probe and find out what exists below the surface, to find the truth. His love of discussion was part of this; through candid verbal exchanges, he could find out more about people, how they felt about issues, and why. He could learn from them. His love of learning (his office was filled with books on every subject) was reflected in something he wrote in last year's Reports to the President:

“...the key challenge before us is to build on what we have learned – indeed, to continue learning – about how to do things differently in the interest of continual improvement.”

Constantine’s confidence played an enormous role in his work with his staff. He never seemed defeated by circumstances that would have crushed anyone else. His poise under pressure acted as a morale-booster to those of us with more wavering outlooks. His eternal confidence that we could succeed acted as a support, but it also challenged us to “come up with the goods,” because he did not pander to our self-doubts or fears. Thus, he challenged us to go beyond what we believed we could do. And we were the stronger for it.

Two examples of Constantine’s accomplishments in his MIT career demonstrate some of the characteristics that defined him. One was his program Building on Differences, which, in his own words stemmed from the

“...challenge of learning how to identify, welcome, respect, and build upon different personal backgrounds, interests, and points of view in order to achieve greater cooperation and teamwork with colleagues at MIT, thereby helping each of us to do our own job better.”

An ever-present theme in Constantine’s repertoire was the value of team, of connection, of bridges between people, of community. He did not simply pay lip service to these ideals; he embodied those values in the way he worked.
Perhaps his most notable and dramatic achievement was as chief strategist in MIT's financial aid antitrust case. The victory was only possible because of his extraordinary courage, his optimism, his belief in equal opportunity, his unwavering faith in the rightness of MIT's position, and his willingness to take on a fair fight.

Constantine's loyalty and personal dedication to MIT were bound up with the role the Institute played in his own life: MIT was an extension of his family, and his family life was inextricably woven into his MIT life; it was all one, and we were all part of his family. Work and personal relations merged in a way that was unique at MIT. We often wondered what was the source of his seemingly inexhaustible energy and devotion; perhaps it was that seamlessness in his way of being.

Constantine's sense of humor, warmth, and generosity of spirit permeated his work and play. He approached life with open arms and embraced it; everything he did grew out of a passion for living.

The loss to those who loved Constantine and to MIT cannot be measured; there is a void here that will never be filled. But we should remember him in a celebratory mood as well, for he lived joyfully to the very end.

Constantine, I know you're somewhere reading this. Take heart. We are carrying on.

KATHRYN A. WILLMORE
Office of the Secretary of the Corporation

The Secretary of the Corporation serves as the Corporation's Recording Officer and as joint signatory with the President in the awarding of academic degrees. The Office of the Secretary of the Corporation is responsible primarily for providing support to the Institute's governing board and twenty-six Corporation visiting committees.

CORPORATION MEETINGS

Orientation Program
On September 30, 1993, the day preceding the annual meeting, an orientation program was held for new members of the Corporation. There was a luncheon at the President's House, presentations by officers of the Corporation, and a campus tour. New members and their spouses/guests were joined by the Executive and Membership Committees for a reception and dinner.

Annual Meeting
At the annual meeting on October 1, 1993, new members were introduced. The Corporation approved the action of the President in the awarding of September degrees; one new degree in Electrical Engineering and Computer Science; one new program in the History and Social Study of Science and Technology; and an amendment to the Bylaws of the Corporation. Members heard reports from the President; Treasurer; Vice President for Resource Development; and from the chairs of the Auditing Committee, Membership Committee, and three visiting committees. Prior to the start of the meeting, a photograph of the Corporation was taken in the garden behind the President's House. In the afternoon, members and their spouses/guests were invited to attend a tour of the Ocean Engineering test facility, and they were invited to attend an Institute-wide memorial service for Professor Robert R. Shrock.

December Meeting
On December 3, 1993, memorial resolutions were presented in honor of James H. Doolittle and Crawford H. Greenewalt. Resolutions were also presented in honor of the conferral on Phillip A. Sharp, Salvador E. Luria Professor and Head of the Department of Biology, of the 1993 Nobel Prize in Physiology or Medicine. Professor Sharp spoke briefly on the nature of his research and on what it was like to win the Prize. Members heard reports from the President; Vice President for Resource Development; and from the chairs of the Membership Committee, MIT Community Service Fund, and three visiting committees. The Academic Council and other invited guests joined the Corporation and their spouses/guests for lunch. In the afternoon, members and their spouses/guests were invited to join the faculty of the Department of Chemical Engineering for a portrait dedication and reception in honor of Ralph Landau.

March Meeting
On March 4, 1994, the Corporation approved the action of the President in the awarding of February degrees. Memorial resolutions were presented in honor of Gregory Smith. Reports were presented by the President; Vice President for Resource Development; and from the chairs of the Membership Committee, Screening Committee, Corporation Joint Advisory Committee on Institute-Wide Affairs, and five visiting committees. In the afternoon, members and their spouses/guests were invited to attend the dedication of the Edgerton Center in Strobe Alley in honor of the late Professor Harold ("Doc") E. Edgerton.

Commencement Meeting
The quarterly meeting was held on May 27, 1994, prior to Commencement exercises. Memorial resolutions were presented in honor of Constantine B. Simonides, Vice President and Secretary of the Corporation. The Corporation elected Kathryn A. Willmore Secretary of the Corporation and approved the awarding of the May degrees and a new degree in the Sloan School of Management. Members heard reports from the President; Vice President for Resource Development; and from the chairs of the
Membership Committee, Screening Committee, and three visiting committees. Resolutions were also presented in memory of Donald J. Atwood and in honor of the retiring members.

CORPORATION MEMBERSHIP

Completed service effective June 30, 1994
Karen W. Arenson, Jennifer L. Lund, and Dolores Wharton.

Elected to a five-year term effective July 1, 1994

Elected from the recent classes to a five-year term effective October 1, 1994
Mark Y. Wang

Elected to life membership effective July 1, 1994
Alexander V. d’Arbeloff

Ex officio members
Kathryn A. Willmore was elected Secretary of the Corporation effective June 1, 1994. R. Gary Schweikhardt, 1994-95 President of the MIT Association of Alumni and Alumnae, began his one-year term on July 1, 1994.

Transferred to life member emeritus effective July 1, 1993
Frank T. Cary

Deaths
Donald J. Atwood, April 24, 1994
James H. Doolittle, September 27, 1993
Crawford H. Greenewalt, September 27, 1993
W. Beverly Murphy, May 29, 1994
Constantine B. Simonides, April 24, 1994
Gregory Smith, January 25, 1994
Julius A. Stratton, June 22, 1994

CORPORATION COMMITTEES

Advisory Committee on Shareholder Responsibility
D. Reid Weedon, Jr., continued as Chair, with Vice President and Treasurer Glenn P. Strehle serving as an ex officio member. The committee membership included Senior Vice President William R. Dickson as well as faculty and students. Elizabeth T. Harding provided staff support.

The committee met once on April 14, 1994, and conducted two telephone polls on March 24, 1994, and May 12, 1994. Members voted on 35 resolutions submitted to 23 companies whose stocks are held by MIT in its general investments. The two most prominent issues were related to the CERES Principles (5 resolutions) and to Political Non-Partisanship and Contributions (6 resolutions). Compared to 1993, the number of resolutions increased slightly from 28 to 35, while the number of companies involved stayed the same.

Auditing Committee
Meetings were held on September 30, 1993, and March 3, 1994. Attendees at each meeting included Auditing Committee members; MIT’s independent public accountants, Coopers & Lybrand; and appropriate members of the MIT administration.

Financial statements for the year ended June 30, 1993, and a report on recent audit developments were discussed at the fall meeting. The MIT Audit Division’s review of current plans and prior year results; Coopers & Lybrand’s audit plan for the year ending June 30, 1994; new Federal accounting
requirements; the impact of two major new accounting standards, SFAS 116 and SFAS 117 (relating to accounting for contributions and financial statement presentation respectively); and the reengineering effort being undertaken by the Institute were discussed at the spring meeting.

**Corporation Joint Advisory Committee on Institute-Wide Affairs (CJAC)**

It was the consensus of committee members that one of the continuing concerns on the MIT campus is the recruiting and retention of underrepresented minorities and women as faculty and as graduate students. Accordingly, CJAC decided that the subject of mentoring would be its principal focus for the academic year 1993-94. Three of the five meetings held during the year were spent in focus group discussions – the first with nine African American undergraduates, the second with nineteen African American graduate students, and the third with six African American faculty. CJAC will issue a report on its findings and recommendations in the fall of 1994.

Stanley G. Hudson, director of Student Financial Aid, and Norma McGavern-Noland, director of UROP and coordinator of the Educational Studies Working Group, met with CJAC to discuss and seek input on the Class of '94 exit questionnaire.

Provost Mark Wrighton met with CJAC to report progress on the initiatives to assist academic departments in adding underrepresented minorities and women to the faculty. CJAC also received progress reports on the guide *Dealing with Harassment at MIT* and on the Family and Work Council.

CJAC continued to encourage interaction between Corporation members and students. Three trustees met with student groups the night before the December Corporation meeting.

**Development Committee**

This committee is covered in the annual report of the Vice President and Treasurer.

**Executive Committee**

During the past year the Executive Committee held ten meetings. Its agenda covered all of the Institute's important decisions and deliberations throughout the year. Notable topics included the Department of Justice's dismissal of the antitrust case against MIT, reengineering of major administrative services in order to improve their efficiency and quality, and the reorganization of the Administration resulting from the sudden death on April 24 of Vice President Constantine B. Simonides.

**Investment Committee**

The Investment Committee held three regularly scheduled meetings during the 1993-94 fiscal year. The Wellington Management Company of Boston remained the primary investment manager and advisor for publicly traded securities, both domestic and international. The Institute continued the program (managed by three other investment firms) initiated last year of equity investments in smaller capitalization companies. In addition, the program for domestic and international alternative investments to publicly traded securities was continued. These alternative investments – including venture capital, private capital, and real estate – are typically managed by several investment managers through pooled investment funds.

**Membership Committee**

The Membership Committee held three meetings and one teleconference during the academic year to discuss substantive membership matters.

**Screening Committee**

The Corporation Screening Committee for Nomination of Recent Graduates held an open meeting for students on October 26, 1993. Two teleconferences and two committee meetings were held in January and February. The committee chose a ballot of ten nominees (one of whom withdrew because he was planning to continue with graduate studies at MIT) from a group of 52 candidates. Mark Y. Wang '87 won the nomination and was elected to serve a five-year term on the Corporation.
The Whitaker College Visiting Committee did not meet in the spring of 1994 since the Department of Brain and Cognitive Sciences had moved administratively from Whitaker College to the School of Science. The new Brain and Cognitive Sciences Visiting Committee will meet in 1994-95. The remaining portion of Whitaker College will continue to be reviewed by the Health Sciences and Technology (HST) Advisory Committee, which will be co-chaired beginning in 1994-95 by a Corporation member.

In 1993-94 the Institute's 26 visiting committees were comprised of 385 persons and 457 membership positions: 61 Corporation members filled 127 slots; 172 presidential nominees filled 176 slots; 154 alumni nominees filled 154 slots. (Two persons each filled both a presidential nominee slot and an alumni nominee slot.) The membership included 17 percent women and 11 percent underrepresented minorities; 60 percent of the members were affiliated with corporations, 31 percent with academia, 5 percent with government, and 4 percent with foundations. There were two resignations: Bruce J. Wrobel resigned from the Athletics Visiting Committee in March 1994; William Clay Ford, Jr., resigned from the Sloan School Visiting Committee in June 1994.

PERSONNEL CHANGES

Office of the Chairman
Frances G. Gallant, at MIT since 1989, retired as Administrative Secretary effective June 30, 1994. Karen M. Tenney, who had been at MIT since 1980 and had been Administrative Assistant to Paul E. Gray since 1981, left the Institute on June 30, 1994, in order to pursue new interests. Susan L. Kendall, at MIT since 1980, became Administrative Assistant to the Chairman, effective July 1, 1994.

Office of the Secretary
Lois A. Graham, at MIT since 1983, was promoted to Associate Secretary effective July 1, 1993. Cathi A. Di Iulio, at MIT since 1991, was promoted to Assistant Secretary effective May 1, 1994.
This year saw a positive change in the national college admissions scene for the first time in many years. Although the high school class graduating in 1994 is the first to show an upward trend in numbers since 1979, the real cause, according to most observers, is the improvement in the economy. Another factor is the success some institutions like MIT have had in drawing a truly national student body and the influence of various rankings of colleges in the media in which MIT and similar institutions are highly ranked. Many such institutions had increases in applications this year, and some had an increase in yield. Outside of this group of institutions, however, the picture is still grim. Most colleges and universities are still having great difficulty reaching enrollment goals.

At MIT, there were several new initiatives, described below, which resulted in a particularly successful year even among that group of institutions which saw improvements. Applications from US citizens and permanent residents increased by 15 percent, led by a 27 percent increase in applications from women. Applications from international students decreased by 2 percent, so the increase in the total application pool was 11 percent. The yield on accepted applicants increased from 50 percent to 51 percent, the first increase in many years.

There was once again a great deal of variation in the financial aid awards received by individual students from the colleges to which they had been admitted. Reports from secondary school guidance counselors indicate that many students applied to more colleges so that they could compare awards and try to get their college of choice to match a higher award from another institution. This bargaining has added a very unfortunate element to the admissions process.

Due to the unusual increase in applications from women, this year’s entering class will be 40 percent female. This is a very important milestone. Especially noteworthy is our successful effort to enroll more women who score very high on standardized tests. In this class, 31 percent of the women are from the high scoring cohort compared to 23 percent last year and 14 percent in 1992. We also met success in increasing the number of students who identify themselves as African American, Mexican American, Native American and Puerto Rican. There are 170 students from these groups this year, compared to 153 last year. We are especially pleased that the number of African American students has increased from 54 to 76 in those two years. This success is especially noteworthy in that all three staff positions related to minority student recruitment saw turn-over this year. We have a very strong team in place now.

Participation by faculty in the selection process declined again. Twenty-one read applications compared to 36 last year and 40 in 1992. There was a slight increase, from six to nine, in the number who read more than 30 cases and qualified to participate in the actual decision making. We again had good lines of communication between our office and various concerned departments to make sure that students with exceptional accomplishments in specific areas were recognized and admitted. This may account for the decline in faculty participation in the general process.

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<th>ADMISSIONS FOLDER READINGS</th>
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<td>Admissions officer</td>
<td>8700</td>
<td>9100</td>
<td>8500</td>
<td>9500</td>
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<td>Faculty</td>
<td>700</td>
<td>890</td>
<td>620</td>
<td>400</td>
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<td>Administrative staff</td>
<td>3000</td>
<td>2400</td>
<td>2200</td>
<td>1500</td>
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<tr>
<td>Athletic staff</td>
<td>na</td>
<td>425</td>
<td>590</td>
<td>550</td>
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After using Total Quality Management tools two years ago to identify our needs, we produced a new Viewbook for use in this last recruiting cycle. It was extremely well received and won several awards including a CASE Gold Medal and an Annual Admissions Advertising Gold along with inclusion as one of the ten "Best of Show." We also produced new application materials including a TQM inspired flow chart which applicants liked very much. The new application had two parts, which allowed for more efficient processing. A new approach to building our inquiry pool from the Student Search Service greatly increased the size of that pool. Applying TQM tools to our application processing resulted in detailed flow charts and the addressing of many "parking lot issues." It also helped us reduce our data entry staff by one FTE. All of these changes have produced a much more coherent and effective recruitment and processing flow of activities.

TQM tools were also applied to our campus visiting program. Our latest surveys show that the changes which resulted have had a significant positive effect.
We continue to investigate the possible benefits from optical scanning and the electronic transfer of some data elements. Experience at other institutions suggests that an ideal approach has not yet been developed. We think this will change rapidly, however, and expect to be doing something in these areas within the next year.

Transfer applications declined slightly again due to the continued use of more rigorous screening of preliminary applications. We developed a transfer credit evaluation database. This will give the department credit examiner a history of the credit given for courses from each sending university as well as the MIT department's transfer credit history.

MICHAEL C. BEHNKE

EDUCATIONAL COUNCIL

The Educational Council included 1660 alumni/ae this past year, representing MIT in all 50 states, the District of Columbia, Puerto Rico, The Virgin Islands, and 47 foreign countries. This group included 322 women and 63 minorities (39 Blacks, 7 Puerto Ricans, and 17 Mexican-Americans). The Educational Counselors represented MIT at 204 local College Fair programs; they conducted 7139 admissions interviews, an eleven percent increase over last year, and held countless conversations with prospective MIT students and with local school personnel. Of all MIT applicants, 87 percent (88 percent within the United States) were interviewed by a local Educational Counselor.

Project Contact is a program which puts current undergraduates in touch with applicants, Educational Counselors, and school personnel. This past year 490 students, representing 152 different geographic areas (including 24 foreign countries), participated in this program run by the Educational Council Office.

Meetings for newly admitted students were held in 39 cities throughout the United States by Educational Council groups. Twenty-nine of these meetings were held during MIT's spring break, and Marti Ward organized panels of current students to speak at each of these meetings.

MIT Open House Meetings were held throughout the United States in the fall and this past spring. Local Educational Council members assisted members of the Admissions staff in arranging for 103 Central Meetings in 95 cities.

Another program supported by the EC office was the AMITA High School Visiting Program. Ms. Ward ran this program, and coordinated the efforts of 90 volunteers, all women professionals (from AMITA, SWE, AWIS, AWM, or other women's professional organizations) to make 42 visits to 38 high schools and 2 junior high schools throughout the Greater Boston Metropolitan Area. They spread the word to young women (and in some cases young men) about the importance of continuing to study math and science in order to keep career options open.

The MIT admissions videotape continues to be extremely popular, and requests for it continue to increase. Requests have come from seventy-seven high schools, eighteen colleges, forty Educational Counselors, twenty-eight prospective students, seventeen MIT offices, and nine current MIT students. Thirty copies have been sold.

The MIT Alumni Award program is in its forth year. The award, given to high school juniors for outstanding achievements, especially in areas of math and science, was sponsored by four alumni (all Educational Counselors) this year. MIT alumni/ae and/or MIT Alumni Clubs can sponsor an award for $25. The award winners receive a certificate in a leather MIT case and a year's subscription to Technology Review. Four awards were presented this year.

VINCENT W. JAMES
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<td><strong>ADMISSIONS TRENDS 1985 - 94</strong></td>
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<td><strong>Entrants from Secondary Schools</strong></td>
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<td>Preliminary applications</td>
<td>14,698</td>
<td>14,349</td>
<td>16,237</td>
<td>17,408</td>
<td>17,832</td>
<td>17,941</td>
<td>20,169</td>
<td>17,423</td>
<td>19,136</td>
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<td>7,437</td>
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<td>6,426</td>
<td>6,481</td>
<td>6,652</td>
<td>6,410</td>
<td>7,139</td>
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<td>Admissions offered</td>
<td>1,885</td>
<td>1,762</td>
<td>1,826</td>
<td>1,833</td>
<td>2,018</td>
<td>2,051</td>
<td>2,012</td>
<td>2,219</td>
<td>2,141</td>
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<td>Actual registration to date</td>
<td>1,061</td>
<td>991</td>
<td>1,001</td>
<td>992</td>
<td>1,045</td>
<td>1,084</td>
<td>1,049</td>
<td>1,157</td>
<td>1,093</td>
<td>1,107</td>
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<td>Registrations as percent of admissions</td>
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<tr>
<td>Number of secondary schools represented</td>
<td>56.2%</td>
<td>56.2%</td>
<td>54.8%</td>
<td>54.1%</td>
<td>51.2%</td>
<td>52.9%</td>
<td>52.1%</td>
<td>52.1%</td>
<td>50.9%</td>
<td>51.3%</td>
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<td>Percent of students from 9 northeastern states</td>
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<td>College Transfers</td>
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<td>Total applications</td>
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<td>870</td>
<td>905</td>
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<td>838</td>
<td>839</td>
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<td>Admissions offered</td>
<td>131</td>
<td>137</td>
<td>106</td>
<td>141</td>
<td>103</td>
<td>118</td>
<td>91</td>
<td>77</td>
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<td>Actual registrations</td>
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<td>Graduate Students</td>
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<tr>
<td>Total applications</td>
<td>8,032</td>
<td>8,564</td>
<td>8,443</td>
<td>8,863</td>
<td>8,655</td>
<td>9,445</td>
<td>10,002</td>
<td>10,714</td>
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<td>Admissions offered</td>
<td>2,467</td>
<td>2,457</td>
<td>2,243</td>
<td>2,101</td>
<td>2,549</td>
<td>2,378</td>
<td>2,338</td>
<td>2,359</td>
<td>2,341</td>
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<tr>
<td>Actual registrations</td>
<td>1,338</td>
<td>1,105</td>
<td>1,019</td>
<td>1,104</td>
<td>1,437</td>
<td>1,169</td>
<td>1,179</td>
<td>1,211</td>
<td>1,145</td>
<td>1,159*</td>
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<td>Registration as percent of admissions</td>
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*expected to register; actual number is not available
INTRODUCTION

The Department of Athletics, Physical Education, and Recreation (the department) has concluded another year of commitment to continuous improvement of the various opportunities and services provided to students and the MIT community.

The department is in possession of one of the finest athletics, physical education, and recreation programs in the United States. Today MIT has an extraordinary 39 varsity intercollegiate programs (24 teams for men and 15 teams for women) in addition to 34 club programs and 16 competing intramural teams. The department's mission is ...

To provide an adaptive, high quality, student-oriented physical education, recreation, and athletics program that emphasizes participation, competition, confidence, and leadership. To enhance the entire MIT human environment for the entire MIT community.

Achieving athletics excellence in the 21st Century will involve a three-pronged approach: (1) the continued enhancement of faculty excellence; (2) ensuring the construction and programmatic development of the new Central Athletics Facility (Phase III); and (3) the concurrent upgrade and maintenance of existing facilities.

Select immediate objectives and planning for the future objectives are:

Immediate Objectives

(1) Continue to promote the outstanding achievement of our students in all sports programs.

(2) Continue to operate a fiscally sound athletics program. Continue professional development and employment of a high quality staff for retention purposes.

(3) Develop a Five Year Management Plan of the department for finance and budget, and programs.

(4) To reduce and balance a serious operating gap between escalating expenditures and a flat operating budget given a projected 2 percent or greater annual budget reduction over the next three fiscal years (1995, 1996, and 1997). The department will review the economic implications of managing the its' broad-based programs and, continue to collect data regarding the budget-revenue-expense trends for an aggregate review of its impact across all programs.

(5) Develop Mr. and Mrs. Katz Field, acknowledgement site, and celebration of the gift.

Planning for the future objectives
(1) See through the implementation of the Central Athletics Facilities (Phase III) planned construction, development project, and review of programmatic needs.

(2) Develop an Athletic Department master plan of facilities in concert with the MIT plan and update as a working document.

(3) Build a strong base of Alumni/ae Friends of MIT Athletics.

(4) Develop a strategic plan for the review of all educational activities in athletics, physical education, and recreation which will include the participation of constituent groups (students, coaches, instructors, Medical Department representatives, Physical Plant representatives, and others.

OVERVIEW OF THE 1994 VISITING COMMITTEE REPORT

On March 30 and 31, 1994, the MIT Corporation Visiting Committee for Athletics was convened by its chair, Howard W. Johnson, President Emeritus and former Chairman of the Corporation, and concluded that it was impressed again by the scope and quality of athletics programs at MIT. The committee's activities included the following: a review of its past recommendations and the department's responses; a full and complete review of several difficult problems and potentials before the department; the range of decisions facing the leadership of the department and MIT administration as they seek to strengthen the quality and effectiveness of the department; an extended tour of the athletics facilities; a view of the future athletics master plan presented by O. Robert Simha, Director of Planning at MIT; a review of the state-of-the-department presentation by Professor Richard A. Hill, and Vice President Constantine B. Simonides, to whom the department reported at that time; and a closed meeting with faculty/coaches and undergraduate and graduate student-athletes, including members of club and intramural programs.

The committee acknowledged that the new director's transition was taking too long; and the director should be encouraged to press forward in developing innovative ways, strengthening the already excellent reputation of the department. This conclusion does not underestimate the difficulties which come at a time when financial operating pressures are great. The current Central Athletics Facility (Phase III) plans were reviewed with a recommendation to reassess, reconceptualize, and redefine the existing plan to one that is more readily achievable. The current total is $55 million to be developed in three phases on land designated between Briggs Field, duPont, and the Howard W. Johnson Athletic Center. In the meanwhile, the committee discussed other well-used and over-used facilities--indoors and out--that require constant refurbishing and rebuilding.

The committee commended the department for good progress made in several areas reviewed in the past: for example, increased open hours at the gym, new efforts in partnership with the Alumni Office to contact alumni and alumnae through "Friends" groups, a new MIT Sports Annual to promote information about intercollegiate athletics at MIT, integration of the department with the information technology system of the campus in general, and demonstrated achievement in the area of gender equity.
Issues where continued efforts should be made included better locker facilities for women at the Pierce Boathouse; improved MIT team rooms; better monitoring of the situation with respect to food service hours after 7 pm; further work with scheduling conflicts in the 5 to 7 pm window; investigation of other space that might be available for outdoor sports, for example, University Park; and better monitoring of facilities operation for optimal use. More productive effort is required in attracting and retaining minority staff when openings become available.

The committee heard for the first time comments about the need for increasing security in the athletics and recreational activities areas to limit unauthorized use of MIT facilities. The members perceived that this would require a radical change in MIT's present security policies.

In conclusion, achieving excellence in the 21st century will involve a three-pronged approach. Over the next two years, this is what the department proposed to do: (1) improve and make more efficient everything we do as a department; (2) participate with MIT as a department of MIT in larger programs such as Re-engineering, etc., and (3) update this report in two years and indicate that we have made significant progress on the Central Athletics Facility (Phase III) plan. The successful management of the nation's largest intercollegiate program will not remain without new efforts, new vision, and eventually, new money. Effective individual physical development, the development of lifetime interest in exercise, and the inculcation of long-range healthy habits have produced superlative results for men and women of MIT over the years.

PHYSICAL EDUCATION

Curriculum and Staff
During Registration and Orientation (R/O) Week, the department's faculty led by Gordon V. Kelly, Director of Physical Education, provided new leadership of the MOYA project which reportedly was very successful.

Registrations for 1993-94 were 8549, 354 less than last year and 465 less than the record of 1991-92. Most significantly, freshmen registrations were down 341 this year. Fifty-five courses were offered (one less than last year); five were dropped while four were added. The highest registrations were aerobics (1639), skating (887), tennis (628), weight training (593), dance (518), and aquatics (517). A traverse rock-climbing wall was added, and a course will be offered commencing with the fall term.

During IAP 34 classes were offered, which is a new high, plus two non-credit seminar-type courses (Swim Stroke Analysis and Inside Pro-Wrestling). Registrations for credit courses numbered a record high 1619 with 919 students registered for credit and 655 receiving credit. Skating, again, had the most registrations at 159 with skiing second at 142.

The 1993 summer program offered 10 activities, namely, various aerobics classes, golf, sailing, scuba, tennis, and weight training.
The department's full-time staff continued at 23, and the part-time staff numbered 45 for 1993-94.

CLUB PROGRAMS

A total of 688 students (213 women, 475 men) participated in 32 club sports during 1993-94. One new club was added; Capoeira, an intense exercise fitness program set to Brazilian music, and two clubs were inactive—cheerleading (football) and dance.

COMMUNITY RELATIONS AND SPECIAL EVENT PROGRAMS

Department facilities were utilized for 43 community relations and 70 special event programs during 1993-94.

INTRAMURALS

Statistics for 1993-94 indicate that 17 different sports attracted 836 teams and 8,420 participants (in 1992-93, there were 882 teams and 9,234 participants). To reduce the field-use pressure, 75 percent of soccer (87 teams) and softball games (85 teams) are played on the Omni Turf. Soccer led in participation with 1479 students, and volleyball led in team registration with 154.

INTERCOLLEGIATE SPORTS AND ACHIEVEMENTS OF STUDENT-ATHLETES

Thirty-nine sport programs attracted 1106 participants (i.e., 785 students in 24 men's sports and 321 in 15 women's sports). The overall record for women was 105-87-3 (.538), and for men, it was 173-241-3 (.418). The combined record is 278-328-6 (.459).

Notable Men's Team Highlights

The football team achieved its best season record ever (5-3). The team was led by running back Jose De Leon '97 who rushed for 987 yards in seven games and safety Calvin Newman '96 who was named to the Division III New England All-Star first team. The Cross-Country team, led by All-America Jesse Darley '95, won the Constitution Athletic Conference (CAC) and ranked third nationally in the National Collegiate Athletic Association (NCAA) Division III academic poll. All-America tennis players Jay Muelhoefer '94 and Nick Tsai '94 won a third consecutive Rolex New England Small College doubles championship. In Outdoor Track, All-America Ethan Crain '94 won the 1500 meter run in 3:52.52. Men's Lightweight Crew member Brett Bader '94 was named to the United States Rowing Association (USRA) All-America Academic first team.

Notable Women's Team Highlights

The sailing team captured the Olympians Trophy which is symbolic of the New England Sloop Championship. Cross Country was the second ranked NCAA Division III All-Academic Team. Volleyball won the Eastern Collegiate Athletic Conference (ECAC) Division North Championship. In Fencing, the epee squad won the inaugural New England Women's Intercollegiate Fencing Association Championship. Crew won its second consecutive NEW 8 Championship (Varsity 8 race). In Softball, Coleen Kaiser led both the NEW 8 with 10 wins as a pitcher and MIT with a .459 batting average. NEW 8 players-of-the-year were Kamilah Alexander '94 (Volleyball), and Marjorie Delo '95 (Cross Country). Sailor Danielle Ames '96 won the "A" Division of the
Women's Three Division Intersectional's Regatta. Mary Beth Richards '94 scored a rare Field Hockey hat trick in MIT's 3-0 victory over the University of Massachusetts/Dartmouth. The Crew Team was named to the USRA All-America Academic Team. Mari Casserberg '94 broke the MIT women's basketball scoring record with 1,198 points, and was also the second woman in MIT basketball history to surpass the 1,000 point career scoring mark.

Department of Athletics Award Winners
The Gold Awards (leadership and service) were presented to Craig Andera '94, Jesse Darley '95, and Dionne Chapman '94. The Varsity Club Awards (for outstanding freshman male and female athletes of the year respectively) were presented to Jose De Leon '96 (football) and Sheila Rocchio '97 (gymnastics). Straight "T" Awards (the highest MIT award for athletics excellence) were bestowed upon 17 student-athletes (14 men and three women) in 10 different sports, and upon two teams (women's volleyball and men's gymnastics).

Academic Achievement Awards
NCAA Post-Graduate Scholarship Award winner Brooks Mendell '94 (baseball) led a talented group of 16 student-athletes receiving 16 honors in six different sports.

All-America Honorees
Fourteen students won 15 honors in eight different sports.

Convocation Awards

STAFF HIGHLIGHTS

Gordon Hamilton, Men's Heavyweight Crew Coach, coached several winning boats at the Head of the Charles Regatta (two) and the Masters' World Rowing Championship in Vienna, Austria. Stu Schmill, Director of Crew, coxed the Rochester Boat Club to a Masters' 4 Plus coxswain championship at the Head of the Charles Regatta. Mr. Schmill also received the Community Rowing Outstanding Volunteer Award. Coach of the Year Awards were received by Halston Taylor, Cross Country, CAC; Cindy Gregory, Volleyball, NEW 8 and New England Women's Volleyball Association; Francis O'Brien, Baseball, NCAA Division III Diamond Regional Award; Mayrene Earle, Crew, NEW 8; and Fran Molesso, Gymnastics, first ever ECAC award. Mark Hanak, was named Coordinator of Sports Medicine in August but resigned in May due to family considerations. Roderick Arthur, Assistant Director for Facilities and Operations retired after 30 years of service at MIT, and Eric Sollee, Head Coach of Fencing retired after 23 years of service at MIT. Fran Charles, Varsity Sailing Coach, and his wife combined to win the 210 class national championship for the second time.

RICHARD A. HILL
The changing face of the American economy has led to notable changes in the mix of employers recruiting at MIT and in the kinds of employment in which our students see a future for themselves. One cannot tell whether the Institute's founder, William Barton Rogers, would smile or scowl at the companies which interest many of MIT's scientists and engineers today, but one can believe he would be surprised. The company which drew far and away the largest crowd to a recruiting presentation in 1993-94 was a management consulting firm, McKinsey & Company. Another standing-room only audience came to hear a young MIT banker, Sara J. Sprung, '84, a managing director at Bankers Trust, talk about derivatives. McKinsey, which has begun recruiting advanced degree candidates in engineering and the physical sciences to come in as associates alongside its usual crop of MBAs, made offers to 24 MIT postdocs, PhDs, and master's candidates in science and engineering. It is too early to say how many students found their way to Wall Street, but it is almost certain that they outnumbered those going to such traditional destinations as the oil and chemical industry, the defense sector, or heavy manufacturing. We welcomed more recruiters from the financial sector than from any industry save civilian electronics (if one groups under this heading semiconductors, computers, peripherals, communications systems, and other electronic devices).

Employers recruiting at the central careers office at MIT in 1992-93 and 1993-94, compared with 1982-83

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<tbody>
<tr>
<td>Oil, chemicals, materials, food</td>
<td>13.2%</td>
<td>8.4%</td>
<td>8.6%</td>
</tr>
<tr>
<td>Pharmaceuticals, medical research</td>
<td>2.0%</td>
<td>3.0%</td>
<td>2.3%</td>
</tr>
<tr>
<td>Biomedical devices, hospital products</td>
<td>0.7%</td>
<td>2.7%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Computers, semiconductors, communications</td>
<td>14.3%</td>
<td>13.2%</td>
<td>11.4%</td>
</tr>
<tr>
<td>Other civilian electronics, diversified electronics</td>
<td>12.6%</td>
<td>8.6%</td>
<td>10.0%</td>
</tr>
<tr>
<td>Mechanical &amp; electro-mechanical products</td>
<td>6.3%</td>
<td>6.2%</td>
<td>5.4%</td>
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<tr>
<td>Design, construction, engineering services</td>
<td>6.9%</td>
<td>4.9%</td>
<td>4.6%</td>
</tr>
<tr>
<td>DOD &amp; DOE contractors, federally-funded labs</td>
<td>19.7%</td>
<td>8.3%</td>
<td>9.4%</td>
</tr>
<tr>
<td>Software firms</td>
<td>4.3%</td>
<td>15.4%</td>
<td>12.0%</td>
</tr>
<tr>
<td>Information systems consulting</td>
<td>2.6%</td>
<td>4.0%</td>
<td>6.9%</td>
</tr>
<tr>
<td>Management consulting, economics consulting</td>
<td>3.7%</td>
<td>8.1%</td>
<td>8.6%</td>
</tr>
<tr>
<td>Financial institutions, insurance</td>
<td>4.6%</td>
<td>12.9%</td>
<td>14.3%</td>
</tr>
<tr>
<td>Government agencies, armed services</td>
<td>5.4%</td>
<td>1.6%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>3.7%</td>
<td>2.7%</td>
<td>4.3%</td>
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<td></td>
<td>100.0%</td>
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The statistics are startling. Not many more than half the employers recruiting through our office this year were engaged in the research, design, or production of material things. Forty-two percent were either software firms, information systems consulting firms, management consulting firms of one sort or another, or banks (or in a few cases insurance companies). The corresponding figure last year was 40 percent. A decade ago it was 15 percent. Downsizing in many manufacturing industries is undoubtedly responsible for some of the tilt in the numbers, but it is surely also a reflection of the looming importance of the service sector in the economy. While manufacturing firms can be expected to resume more active recruiting in the years ahead, the service sector will offer increasing opportunities for graduates with technical skills. The engineering profession, which grew up hand-in-hand with the building of America's industrial skyline, finds itself in a very different landscape as the twentieth century draws to a close.

The presence of so many service-sector firms maintained recruiting at a high level, notwithstanding the uncertain economic times. Three hundred and ninety-three separate organizations conducted interviews, compared with
382 in 1992-93. They included 368 companies, 9 government agencies, and 2 educational institutions. Between them they conducted 9,729 interviews (up from 9,384 in 1992-93). Over a quarter of the interviews (2,582) were with management consulting firms, information systems consulting firms, and financial houses, corresponding closely with the representation of these three groups on the recruiting roster.

Salary offers showed very little change from 1992-93, except at the master’s level in some engineering fields. Offers to masters in electrical engineering, for example, were up 4.8 percent. Offers to PhDs were down rather than up. These have been hard times for PhDs and many have come to the office seeking advice. They have been among our most attentive clients. Once again we offered a series of talks in IAP on “Opportunities for PhDs outside the Laboratory”.

Medical school
The changing interests of students have also been reflected in a surge in applications to medical school, matching a surge in the nation as a whole. The Association of American Medical Colleges reports that 201 MIT students and alumni applied for admission in 1994 compared with 176 in 1992-93. We have not seen so many applicants since the years immediately following the Vietnam War. They hit a peak then of 186 in 1975. Our office worked with 160 candidates this year compared with 143 in 1992-93; 105 of them undergraduates, 10 graduate students, and 45 alumni. Last year 74 percent of MIT’s undergraduate candidates were accepted, 90 percent of the graduate students, and 59 percent of the alumni. This year the increase in the national numbers will have lengthened the odds but we still expect good results.

ROBERT K. WEATHERALL
INTRODUCTION
The Department continues to provide quality health services, preventive, diagnostic and therapeutic, for our various constituencies through our Student Health Service, MIT Health Plans and employee benefit programs. Two additional major activities occupied time and effort as preparations were made for the October 1993 Joint Commission on Accreditation of Healthcare Organizations (JCAHO) survey and the Department’s strategic planning process evolved.

The Department was accredited with commendation, a three year award. This honor is bestowed to approximately 4 per cent of organizations surveyed and this includes from major teaching hospitals to tiny community facilities. This benchmark of our organization has been a huge psychological boost as we face the reality of competition in the marketplace where we have no advantages of scale, only of quality effort.

Strategic planning has been a consuming effort that is about to culminate in a plan that will incrementally bring us into stronger competitive advantage and at the same time lead to cost reductions. The presentation of our plan will be amplified by a document that will be made available to Institute officers, the Medical Management Board and the Corporation.

MEDICAL CARE ACTIVITIES
Dental Service: Cynthia Stevens, D.D.S., Chief
In response to internal and external evaluations of the Dental Service last year utilizing an outside consultant, important goals for the Service have been met including increased revenues and number of encounters. These improvements reflect a tighter organization of the Service, better track of patients and billing as well as attention to high quality and personalized service. The addition of a skilled prosthetics dentist, Dr. Ronald Tracy, has added greatly to the overall efficiency and quality of the Service.

Medical Service: William A. Ruth, M.D., Chief
The primary internal medicine group had a productive year seeing approximately the same number of patients while absorbing the loss of two colleagues. The group responded to the need to examine our practices and increase our value by improved efficiencies. Monthly meetings were dedicated to examining how practice patterns could improve and redefining the concept of a full time position within MIT’s framework of needs and Department’s goals. In addition to the monthly meetings, educational activities included two clinical conferences per month for review of ambulatory patients, a weekly luncheon conference and a variety of consultative interactions. Teaching included fellows, residents from Mount Auburn Hospital, interactions with moonlighters from the major teaching hospitals in town, especially the Massachusetts General Hospital, a course given to Health, Science and Technology (HST) first year students and involvement with the Medical Engineering Medical Physics (MEMP) group during their second year Introduction to the Clinic.

The first medical staff retreat at Endicott House provided the opportunity to discuss our practice in depth and to begin to benchmark this practice with similar medical practices in the city. From the retreat a greater awareness of the business aspects of the Department emerged as well as the opportunity to share ideas to improve the efficiency of how we do our work. Enthusiasm for the retreat clearly encourages other such meetings in the future.

Various aspects of Medical Service activities have been realigned during this year. Dr. William Ruth became Chief of Medicine; Dr. N. Martha Pedraza is responsible for stress testing; and Dr. Michael Kane is responsible for scheduling of primary care practitioners. The new library developed under the leadership of Dr. Michael Myers is now being utilized for immediate reference. We continue to consider more flexible hours to meet the needs of patients and their families.

Off Hours Service: Leigh M. Firn, M.D., Coordinator
Emergency and urgent care needs of the MIT community continue to be provided on a twenty four hour, seven day a week basis by the Off Hours Service. The 8,000 visits this year represent a modest increase over the previous year and point to our efforts to accommodate people who walk in after the time appointments can be scheduled. A significant operational change has been the creation of a pool of moonlighting pediatricians to
provide direct patient care during busier hours on the weekend for younger members of the Health Plan and student spouses. Needs are continuing to be evaluated on an ongoing basis through focused quality assurance reviews on common medical problems seen, on updating medical equipment and medications and reeducating staff in newer emergency procedures.

Inpatient Medical Service: Elaine L. Shiang, M.D., Chief
The number of admissions to the Inpatient Unit and the average length of stay at 5.5 days has not changed appreciably over the past year. There was also the same number of Clinical Research Center (CRC) patients cared for numbering 366 days of care. The Inpatient Unit is being reviewed as part of the overall strategic planning process for the Department. This review includes the specified operating budget, personnel structure and ideas for utilization of the Inpatient Unit. Recommendations regarding potential operational improvements have been made by a small subcommittee and these will be further refined and developed as we move into open enrollment and into implementing aspects of the strategic plan. While the Inpatient Unit continues to service broad segments of the MIT community in exemplary ways, we are hoping to develop the means to increase the percentage of beds that are filled and therefore cut down the cost per patient. Part of this increase will come from directing patients who might otherwise go to a high cost in town hospital to receive their care at MIT. Parenthetically, surgical patients and orthopedic surgical patients are quickly returned to the Inpatient Unit for continuing care as well as for convalescence.

Obstetrics and Gynecology Service: Charles F. Eades, M.D., Chief
The staff received a tremendous boost with the arrival of two new physicians, Dr. Lori Ann Wroble and Dr. Carey York. They both have gained warm acceptance from patients and the working staff and help to bring much needed services in patient care while at the same time diminishing the queue for patients to a minimum number of days. Dr. Eades retired from his obstetrical practice and continued during the year to provide gynecologic care for patients. Deliveries remained at approximately the same as last year and the annual rate of Caesarean procedures at 8.3 per cent was well within community standards.

A major effort of the Service as part of a multi-discipline area approach was the Infertility Consultation Committee which is chaired by Karen Halvorsen, R. N. As coordinator of this committee she oversees the care of a large number of infertile women/couples who are receiving treatment through outside consultants. She also provides direct care to an additional complement of women/couples. We look forward to bringing more activities in house for the convenience and comfort of our patients and as a cost effective measure.

Pediatric Service: Mark A. Goldstein, M.D., Chief
In addition to its continuing activities, the Service reviewed after hours care for children and developed a program for pediatricians to be on site during weekends and holidays. A cost containment and efficiency review was launched by the Service and ongoing meetings were initiated with Social Work and Psychiatry to improve the care given to our mutual patients.

Psychiatric Service: Peter Reich, M.D., Chief
The total number of patients seen by the Psychiatric Service and the total number of individual visits increased considerably this year, for Health Plans as well as for students. Admissions to outside hospitals decreased and total hospital days decreased considerably, an expression of the general trend toward shorter admissions seen throughout the psychiatric hospital system in greater Boston. Since September 1, 1993 a contract with McLean Hospital has been in effect that has reduced the hospital per diem cost significantly. A number of psychiatric and psychology trainees served the Service well and the training program will continue during the upcoming fiscal year. Members of the Psychiatry Service also continue their active work in the MIT community in education, liaison and early intervention.

Child psychiatrist, Elizabeth Childs, M.D., began weekly sessions this year and she has also been a consultant for psychopharmacology as well as an available consultant for Health Plan members about their children. Dr. Reich and others in the Service continue to be intensely involved in the HST program, in the student advisory system, the Curriculum Committee as well as precepting students in the Department rotating here as part of their clinical training. The Psychiatry Service does yeomen work in seeing a vast array of students and staff. In addition it should be emphasized that as a community service, the Psychiatry group and the social workers are often involved in trouble shooting and fact finding efforts that are exceedingly valuable to the mental health of the MIT community.
Social Work Service: Ronald C. Fleming, LICSW, Chief
The Social Work Service staff at MIT contributes to the development and maintenance of an environment which facilitates work, study and research. The staff continues to play an important role in assisting the community as it adjusts to the pressures generated by financial retrenchment, position, attrition and reengineering, all areas that have become a part of the life of the Institute. The Service responded for assistance from 648 persons, 286 of which were new this year.

The Service responds creatively and flexibly to community needs, especially through the use of groups. Refer to last year's Annual Report for the specifics of these groups which include parenting of adolescents, elder care, working parents, cancer support, adult children of alcoholics, etc.

Other activities include serving as a clearing house for self help organizations, involvement in the assistance program of the MIT community, participation in the minority student concerns group and the summer science program at Lincoln Laboratory and on the MIT campus, the program for African American administrators. Elder care issues have been of growing concern and an area of major focus this past year and into the current year.

Surgical Service: Stephen J. Healey, M.D., Chief
The volume of minor and major surgical procedures remains steady. An important activity of the Service is to make maximal use of the Inpatient Unit with referral of patients back from surgery either on the day of the surgery or next day.

Dr. Sheldon Binder retired having provided surgical care for the MIT family for over a 15 year period. In July 1994 Dr. Manson plans to halt his direct surgical activities in orthopedics, but will continue to serve our patients in clinic. The Surgical Service is in the process of developing and expanding relationships with Mount Auburn Hospital and the Massachusetts General Hospital to develop sound referral networks for consultation and treatment of breast cancer.

Nursing Service: Janet V. Beyer, RNC, Chief
The activities of the Nursing Service are far flung with a major role in the ambulatory area staffed by general nurse practitioners as well as subspecialty practitioners in Dermatology, Gynecology and Psychiatry. Additionally the CRC is served by our Nursing Service. At Lincoln Laboratory and in community service activities, infection control coordination and continuing education and quality assurance, the Nursing Service participates in all areas of Department activity. This is the first year of a Nursing Service chaired by a single individual, Ms. Beyer. Her activities coordinated all of the above mentioned array of services in a coherent manner and did not neglect, much to the credit of the Service, the student needs on campus.

OTHER DEPARTMENT ACTIVITIES
Clinical Research Center (CRC): William H. Dietz, M.D., Ph.D., Associate Director
The Inpatient Medical Unit continues to care for the patients who are subjects in CRC grants. Studies relying heavily on the Medical Service support include those involving sensory motor function in elderly patients with Alzheimer's disease plus prospective studies of energy expenditure in preadolescent girls and immunoassay infusions to establish protein requirements in young adults. CRC members continue to participate in a variety of Medical Department activities including presence on multiple major committees.

Environmental Medical Service (EMS): Robert J. McCunney, M.D., M.Ph., Director
This report marks the first for the new Director of EMS. Major activities of EMS have focused on medical surveillance of people exposed to hazardous materials at MIT, Draper, Bates, Lincoln Laboratory and the Whitehead Institute. Many areas including biological safety services, industrial hygiene and radiation protection fall within the purview of EMS and there have been active areas of consultation and interface with each of these groups and many far flung areas of the Institute. With the departure of Daniel Liberman, Ph.D. a new head of Biological Safety Office is being recruited.

Many activities have been directed toward lead in drinking water at Lincoln Laboratory, repetitive strain injuries on campus, responding to new regulations from OSHA, planning for new regulations concerning tuberculosis and indoor air quality. An occupational medicine resident from Boston University Medical Center surveyed hydrofluoric acid at MIT and reviewed emergency response procedures when accidents occurred. An ongoing resident in occupational medicine from Boston University promises to be a stimulating resource within the
Service. Plans are under way to survey the occupational health needs of the Bates Linear Accelerator Laboratory and Lincoln Laboratory. A summary of key activities of the various offices, i.e. Radiation Protection, Biological Safety and Industrial Hygiene are all available in the complete report of the EMS Director to the Medical Director.

Health Education Service (HES): Bethany Block, M.D., Coordinator
The major effort that continued this year was the MedLink program directed by Ms. Tracy Desovich. This program now has sixty students representing all undergraduate campus dormitories as well as thirteen off campus independent living groups including fraternities. In addition to consultations utilizing MedLink students for triage, major student health campus activities of the year included alcohol awareness week, world AIDS day, KISS (keeping intimacy safe and sensual), and annual cholesterol screening and healthfest.

A satellite office, called MedStop, was developed in the infinite corridor, which opened in November and served as a ready access office for health information materials and to connect students with clinical services directly or through referral to the Medical Department. HES increased its visibility within the Medical Department expanding its health information displays as well as developing a larger video lending library and book loan program both of which were greatly appreciated by students and Health Plan members.

HES with input from the Health Education Advisory Committee designed and distributed a needs assessment survey to 2500 undergraduate and graduate students and 2500 Health Plan members. Responses demonstrate that many of HES resources are seen as useful and that nutrition, exercise and fitness and stress management were the areas of greatest concern for people who responded. A search is underway for a new director for HES and a variety of new programs are being designed to fill the needs of students and other members of the community.

Lincoln Laboratory Medical Service: Bruce J. Biller, M.D., Coordinator
Patient encounters remained at approximately 3500. A staff of three saw these walk-in patients and in addition administrative activities developed during the year included a revision of the emergency procedure plan which includes Hanscom Air Force Base, fire department EMT's in first response, quality assurance/quality improvement monitors of nurse and physician clinical care, educational programs which included orthopedics and psychiatry and soundproofing of examination rooms to complete auditory privacy of patient provider encounters.

Student Health Services (SHS): Mark A. Goldstein, M.D., Chief
Five areas of activity related to student health were achieved during this past year. The Student Medical Advisory Council was appointed and discussed areas of mutual concern between the Medical Department and MIT students during five fruitful meetings. The Student Health Service successfully competed for an educational grant of $25,000 to develop educational materials and to subsidize hepatitis B immunization program for students. The premium for student health insurance was able to be maintained at the same level for the second year and this reflected good management of students requiring outside hospitalization. Physicians in the Student Health Service developed many outreach programs with students, parents, faculty and staff. Finally our outreach program for international students was selected for presentation at the American College Health Association meeting as a prototype program for colleges and universities with international students.

Strategic Planning and Clinical Operations: J. Christian Kryder, M.D., Coordinator
Strategic planning activities have been very large in scope during the past year. A committee began meeting in the spring of 1993 with the addition of a consultant, Howard Veit, in November and moved full speed through a process which is being completed in the summer of 1994. Our committee undertook evaluation of current operating strengths and weaknesses, environmental issues, competitive threats and opportunities, our lines of business and reviewed a series of strategic options which would be compatible with the values and principles by which we serve members of the MIT community. The strategic plan in its final stages of development will be presented to various constituencies of the Institute and the Medical Department in the late spring and summer 1994.

Improvement in clinical operations this year took a number of directions and initiatives. In our medical group we are preparing for changes expected with rapidly accelerating marketplace reforms. The importance of medical management information systems and data feedback to physicians is a paramount part of this process. A day long retreat began the process of quantitative review of our medical practices with our primary care physicians and pediatricians in late 1993.
As the marketplace moves increasingly toward quality measurement we have begun to demonstrate quality of our services through a format entitled "Health Plan Employer Data and Information Set" (HEDIS). This format is likely to be exploited by employers in the next few years and our preliminary data indicates that Medical Department physicians have produced substantially higher scores, especially in the area of preventive health maintenance.

Management of specialty services has been largely guided by continuing efforts to maintain or improve quality of services while attempting to reduce costs. There are over 40,000 specialty service visits on an annual basis, a stable number over the past four years despite the group in the MIT Health Plans population. Continuity of care has been optimally maintained for patients in this environment and the specialty services have been well coordinated with primary physicians. Quality assurance reviews of our specialty services remains high. From a cost standpoint we have been able to achieve reductions in Allergy, Neurology, Nutrition, Ophthalmology and Optometry.

Administrative Operations and Management: Michael A. Kane, M.D., Associate Medical Director
The major thrust of changes in operational services has been to simplify and consolidate functions and positions in a year in which financial constraints and our strategic planning efforts moved along. Efficiencies have been realized in the Nursing Service including ambulatory and inpatient areas, in health education especially through expansion of the MedLink program for contact with students and in the very sensitive area of patient advocacy where we have added a second individual to take responsibility for this most important interface. We have made some arrangements for specialty care in Orthopedic and Plastic Surgery, especially through the development of a relationship with the Plastic Surgery Division of the Massachusetts General Hospital. The residency training program has been suspended until the entire Mount Auburn Hospital residency is reviewed centrally. We have continued to be a training site for adolescent fellows from Children's Hospital. The preparations for review for the JCAHO led to a successful survey in October 1993, coordinated especially by Dr. Bruce Biller and Ms. Rochelle Alexander. On the basis of the four member team's careful scrutiny of our programs we received accreditation with commendation. Of special note is that surveyors from the Joint Commission review health care programs as large as major teaching hospital programs and as small as tiny community hospitals and a few university based health care services. In receiving commendation we are acknowledged to be among the very best using the same criteria for all institutions that are surveyed.

MIT Health Plans: Mary P. Smith, Acting Executive Director
We are completing the twenty second year of the traditional MIT health plan and the sixth year of the flexible plan serving employees of the MIT community. The two plans cover approximately 50 per cent of MIT and Lincoln Laboratory employees with a total membership stable at 10,000 members. There are many issues to consider as we compare the MIT Health Plans to commercial HMO's that are offered at MIT. Our costs are higher but we are finding ways to reduce those costs while maintaining the high level of quality and access that our members have come to expect. Inpatient hospital admissions remain our largest cost area. Three hospital contracts were negotiated during 1993 for inpatient psychiatric and substance abuse admissions. We will be pursuing other hospital contractual arrangements.

The drive for value in health care, that delicate balance between cost and quality has moved to center stage in the national arena. Our planning efforts will continue to find avenues to offer continuing value to MIT for its health care services provided on campus while recognizing the enormous financial pressures on the Institute.

Personnel Changes

APPOINTMENTS

Yousef A. Ayyub  Network Engineer III
Linda I. Audin  Chief Radiologic Technologist
Anita L. Bailey  Inpatient Nurse
Georgene P. Bloomfield  Assistant Chief Pharmacist
Maria Concepcion Castells  Allergist
Elizabeth Childs  Psychiatrist
Barbara A. Choate  Inpatient Nurse
Deborah J. Friscino  Chief Pharmacist
Maureen A. Ganley  
Duan-I Lee  
Alex A. Milne  
Robert J. McCunney  
Perry D. Spearman  
Ronald W. Tracy  
N. Lynn Wittman  
Lori Ann Wroble  
Carey M. York  

Nutritionist  
Pharmacist  
Patient Billing Reimbursement Coordinator  
Director, Environmental Medical Services  
Assistant Radiation Protection Officer  
Dentist  
Optometrist  
Obstetrician/Gynecologist  
Obstetrician/Gynecologist

RESIGNATIONS/RETIREMENTS

David E. Bailey  
Sheldon C. Binder  
Richard L. Brewer  
Maureen Dickey  
Elizabeth J. Engelberg  
Michelle Fitzgerald  
James Franco  
Susan D. Freedman  
George G. Goldman  
Shawn Hill  
Gordon B. Kuttner  
Daniel Liberman  
Julie Shipp Mitchell  
Fe Banzon Pastorfide  
Janet A. Pesaturo  
Mary R. Ramos  
Patricia Reardon  
Jean T. Rosowski  
Linda L. Rounds  
Walter H. Rymzo  
David B. Sachs  
David B. Smith  
Janet Van Ness  

Chief Pharmacist  
Surgeon  
Manager, Administrative Services (EMS)  
Co-Director, Nursing Services  
Clinical Psychologist  
Assistant Radiation Protection Officer  
Inpatient Nurse  
Physician  
Allergist  
Network Engineer III  
Obstetrician/Gynecologist  
Biohazard Assessment Officer  
Systems Analyst  
Dentist  
Postdoctoral Fellow, Psychiatry  
Nurse Practitioner  
Inpatient Nurse  
Audiologist  
Executive Director  
Internist  
Network Engineer II  
Physician  
Director, Health Education

Concluding Comment
The departure at midyear of Linda Rounds, Executive Director, and Walter Rymzo, M.D., Chief of Medicine, left significant voids in a year filled with planning and change. The contributions of Mary P. Smith, Acting Executive Director have been instrumental in providing leadership in the Administrative area. Our physician group has responded to the absence of Dr. Rymzo by rallying around the new Chief of Medicine, William Ruth, M.D. The efforts of the entire Medical Department have resulted in a productive year in which we have positioned ourselves to move forward in innovative ways to continue to provide, as a department of MIT, quality care and thoughtful preventive advice through educational efforts.

ARNOLD N. WEINBERG, M.D.
This year we have decided on a new format for our annual report — that is, to launch it with a brief review of the highlights of publishing and program development by our acquisition editors.

Neuroscience

During this fiscal year, the neuroscience publishing program continued to develop into a broad and mature list. The emphasis in terms of money, time, and effort spent signing and developing new books has been on textbooks, large reference works, and authored volumes rather than the loosely edited volumes which tend to be the mainstays of publishers in the biomedical sciences.

Major books signed include Michel and Moore: *Developmental Psychobiology* (undergraduate textbook), Szentagothai et al.: *Neural Organization and Function*, Ulinski: *Computational Approaches to Neural Circuits*, Fuster: *Memory in the Cerebral Cortex*, Freed: *Brain Tissue Engineering* (trade); and Franklin: *Artificial Minds* (trade).

The most important books that have been developed to completion and entered into production during this year are Gazzaniga: *The Cognitive Neurosciences* and Arbib: *Handbook of Brain Theory and Neural Networks*. These are both 1400-page, large format, reference books that promise to make major impacts on their fields and generate healthy income for the Press. Also completed was Johnston and Wu: *Principles of Cellular Neurophysiology*, a 700-page seminal textbook in neurophysiology from Baylor College of Medicine.

Highlights among the books published during this past year include Koch and Davis: *Large Scale Neuronal Theories of the Brain*, Cohen and Eichenbaum: *Memory, Amnesia, and the Hippocampal System*, Barlow: *The Electroencephalogram*; and Gardner: *The Neurobiology of Neural Networks*. Among the neuroscience paperback highlights for the year were LeVay: *The Sexual Brain* and Churchland and Sejnowski: *The Computational Brain*.

Cognitive and Brain Science

Harry and Betty Stanton's activities in the areas of the Cognitive and Brain Sciences and the new Complex Adaptive Systems Sciences included Kosslyn: *Image and Mind*, the long-awaited book by the Harvard psychologist elegantly summing up his twenty-year research program on the nature of high-level vision and mental imagery; Thelen & Smith's *A Dynamic Systems Approach to the Development of Cognition and Action*, a comprehensive, detailed theory of human development based on recent principles of dynamic systems theory, dynamic representation, and processes of change employing complexity theory and radical alternative to current cognitive theory, and Resnick: *Turtles, Termites and Traffic Jams: Explorations in Massively Parallel Microworlds*, foreword by Seymour Papert. Originally entitled *Beyond the Centralized Mind-Set*, this is an original look at 'the new learning theory', using Logo. Children and adults explore decentralized, self-organizing actions for individuals and groups. The book builds on ideas from education, computer science and artificial intelligence, dynamic systems theory, and artificial life.

Koza: *Genetic Programming II* is a major forward development of the author's first book on this topic, which established a new field. Stepping beyond traditional artificial intelligence, neural networks and genetic algorithms, his program solves complex problems automatically, employing populations of reusable computational subroutines and automatic function definition.


Volume II is a volume which, along with Volume I falls directly into line with the new MIT Computational Learning Center (Poggio et alia). This second of the three projected volumes concentrates on computational learning theory, neural network research, and symbolic machine learning.

McGilly (ed.), *Classroom Lessons* is a sequel to the Press best-selling, award-winning trade book, *Schools for Thought*, by John Bruer. This new book documents specific ways of improving classroom learning, using new cognitive research methodology. Its eight major projects, K-12, include writing, reading, mathematics, history, social science, and physical science.

Hassoun and Kasabov textbooks: *Foundations of Artificial Neural Networks*; and *Neural Networks, Fuzzy Systems, and Knowledge Engineering* promise to be the leading first-year graduate textbooks on neural networks for engineers, clearly written and targeted directly at all major competitors. Kasabov's text for graduate engineers has virtually no competition and covers the latest synthesis of three interrelated cutting-edge areas of applied research and design.

The text/reference work by Cohen, *Empirical Methods for Artificial Intelligence* fills a tremendous need in artificial intelligence for empirical methods. Traditional artificial intelligence has almost stalled for want of more rigorous empirical approaches. The book is without competition and will create courses in most major universities. It is accompanied by many pedagogical materials for students. Meanwhile, it will serve as the major reference work in universities and industry.

Churchland: *Engine of the Mind - Seat of the Soul* is a delightfully written extended essay on the mind/body problem. The author uses the current neuroscience approach to build a clear understanding of the functioning brain in a way that never excludes but supports the existence of the human soul.

Landauer, *What's Wrong with Computers?* is a clearly written trade book marshalling all current data to show that the use of computers has not increased productivity in any country in the world. Using interesting examples, the author lays out user frustration and great equipment and maintenance costs, putting much of the blame on unscientific, unimaginative software development and testing, and offering solutions through user-centered software which can meet the high standards of available hardware.
Shaefer's *Adaptive Representation and Genetic Optimization Techniques* is an exciting new approach to optimization methods that seems to out-perform other methods such as neural networks, genetic algorithms, simulated annealing, hill-climbing and Monte Carlo techniques. It is fast, accurate, and constantly searching for optimal solutions to real problems such as protein folding, genetic engineering problems, etc.

Miller builds a beautifully documented case for the enormous growth of the human brain in a relatively very brief time-span, and puts forth the thesis that the evolving human brain is being driven by successful sexual selection in *The Runaway Brain and Sexual Selection*. This is a trade book for the generally-educated reader and should be a hotly debated book. It is highly recommended by many world-known scholars such as John Maynard Smith.

**Psychology and Linguistics**

The mission of the Press psychology publishing program acknowledges that there is less of a firm line than there once was between "hard" and "soft" sub-domains of this field and that there is rigorous work to be documented in social and cultural corners, and a wealth of new interesting research on individual differences in cognition, brain and behavior (e.g. male vs. female, normal vs. impaired). In the linguistics program, the belief is that The Press will hold up better against the encroaching competition from other aggressive publishers if the identity of this list is allowed to grow beyond the two existing series. With these goals and the integration of psychology and linguistics in mind, Amy Pierce, who manages the acquisition program in linguistics and psychology signed a number of strong monographs in the domain of language and behavior. These include Howard Poizner's co-authored *Signs Within the Brain*, a book documenting groundbreaking research into sign language loss resulting from brain damage (aphasia) as compared to motor control loss of another origin. Equally significant is Laurence Leonard's *Specific Language Impairment in Children* which looks at the behavioral manifestations of a genetically-based deficiency in the acquisition of language. Most significant in the area of language is the signing of Al Lieberman's *Speech*, a retrospective of his life's work by the universally acknowledged leader in the field of speech research. Of a more popular nature, *Child Centered Design* is a monograph by the director of interactive technologies at Children's Television Workshop (the producers of Sesame Street), providing a highly informed critique of existing educational technologies. The book with the most trade potential among those signed is Manfred Clyne's *Interpretation of Music*, in which the author sets himself to the task of nothing less than revolutionizing common appreciation of classical music through the use and demonstration of computational algorithms for emotional contouring of machine-generated music.

**Environmental Science**

There were several titles in this year's energy and environment program administered by Madeline Sunley that were significant. Chivian, McCally, Hu, and Haines (eds.)/ *Critical Condition: Human Health and the Environment*, the response of the medical community to the UNCED Rio Conference, and an assessment by prominent physicians of the medical consequences of environmental degradation received an award from the New England Chapter of the American Medical Writers Association for excellence in the Writing for a General Audience Category. Rogers *America's Water: Federal Roles and Responsibilities*, is an analysis of the patchwork of policies that govern the United States water supply sponsored by the Twentieth Century Fund. Barlow (ed.)/ *Evolution Extended: Biological Debates on the Meaning of Life*, is an anthology weaving selections from the writings of biologists and philosophers into a unified whole, exploring a range of viewpoints as it invites readers to form their own opinions. The literary quality of some of the very best writers in biology is matched by Barlow's choice of fine art and biological illustrations; poetry evocative of the text accompanies the major essays.

Important contracts signed in this list included a trio of trade books about environmentalism. *The Search for Ecological Identity* is a preeminent educator's perspective on how adults learn to locate themselves in the environmental spectrum. *American Environmentalism: A Movement Courting Irrelevance* is a critique of the mainstream environmental organizations based in Washington, DC, showing how their intense involvement with wealthy corporate funders, direct mail campaigns and the nuances of life on Capitol Hill have led to limited gains, increased losses for environmental quality, and the alienation of their grassroots support. *In Search of Sustainable America: Success Stories of Sixteen Environmental Pioneers* profiles Americans who are living out their environmental beliefs. Another important trade book signed was *Mending the Ozone Hole*, a scientifically accurate yet accessible book covering all aspects of the ozone issues, from science to technology to policy.

A unique reference work, *The Atomic Atlas: Nuclear Weapons Production Worldwide and its Environmental and Health Effects* is expected to become a standard handbook. *Whose Backyard, Whose Risk: Fear and Fairness in Toxic and Nuclear Waste Siting* by a prominent environmental attorney and law professor, is a comprehensive overview analyzing waste streams, conflicts, and existing policies, and proposing solutions to minimize litigation and maximize siting efficiency and community satisfaction. Hydrologists, environmental engineers, seismologists and geologists will be reading *Solving Problems in Environmental Engineering and Geosciences with Artificial Neural Networks*, a ground-breaking professional-level work.

Two new books were signed in *The Press series* examining international environmental agreements from a political science perspective: *Global Environmental Accords: From Paper to Practice: International Oil Pollution and Treaty Compliance*, and *International Law and Global Environmental Change: Implementation and Compliance with International Agreements*.

*Perils Amidst the Promise: The Ecological Risks of Transgenic Crops in the Global Marketplace* is a reasoned overview of this controversial biotechnology. *Ecological Economics* by a leading theoretical ecologist, examines the mistaken assumptions upon which natural resource and environmental economists base their calculations.

**Architecture, Design, Arts, and Humanites**

During the past year, the MIT Press again distinguished itself for its outstanding publications in art, architecture, design, and photography. Editor Roger Conover, who has been responsible for developing this part of the list for the past 17 years, acquired a number of new titles which promise to continue to bring distinction to this highly visible publishing program over the next couple of years. Perhaps the most noteworthy publication of our visual arts publishing program in
FY94 was Pontus Hultén's monumental Marcel Duchamp catalogue, accompanying the major Duchamp retrospective at the Palazzo Grassi in Venice. Although The MIT Press has co-published many exhibition catalogues with many museums, this represented the first time that MIT Press-secured exclusive English-language rights to one of the blockbuster shows of the decade mounted by a major foreign museum. The book was in play among a number of U.S. publishers, including Abrams and Rizzoli, and the fact that The Press published the book (and went back to press for another printing almost immediately) puts it in contention for other exhibition catalogues of this stature.

Pietro Belluschi, former Dean of the School of Architecture at MIT and renowned architect in the Pacific Northwest, is the subject of a major monograph coming out in the fall by architectural historian Meredith Causen. A most unusual book of industrial archeology, Mimi Melnick's photographic survey of Manhole Covers, was also signed last year. It was the subject of a first-ever preview of an MIT Press book in the New York Times Magazine on July 31, 1994, and has been generating unusually strong interest in the trade press. What Is Architecture?, a book by another first-time author, Paul Shearof, was also published in 1994 to extremely favorable reviews and appears to be headed for a place as one of the mainstays of our backlist. Several books by former MIT Press authors whose earlier works already belong in this category were also signed last year: we especially look forward to new works by Colin Rowe, Robert Venturi, and Kenneth Frampton.

Best sellers in the humanities last year managed by Larry Cohen include two books by Barbara Stafford. The paperback reprint of Body Criticism and the new hardcover Artful Science; and Wiggershaus' major opus in our German Social Thought series The Frankfurt School.

**Computer Science**

While the best seller in computer science last year was the second edition of the New Hacker's Guide (about 10,000 copies in nine months), the real highlights of Terry Ehling's list were a series of advanced texts, including Harvey: Simply Scheme; Sterling: Art of Prolog, second edition; Forbus: Building Problem Solvers; and Forester, Computer Ethics, second edition.

A highlight of the FY94 computer science program managed by Robert Prior was also the shortest book of the list: A Small Matter of Programming: Perspectives on End User Computers, in which Bonnie Nardi, an anthropologist at Apple Computer addressed the important issues in the programming of computers by end users. This elegant little book reflects a renewed interest in the field of Computers and Human Interaction (CHI), an emerging area of research in computer science.

FY94 also saw the publication of three important titles on the relationship of computers to fine arts. The book with the largest audience of these three is Steve Holtzman's Digital Mantras: The Languages of Abstract and Virtual Worlds. In its first three months on the shelves, it had already sold over 4,000 copies and has been the subject of several excellent comments in national periodicals. Michele Emmer's The Visual Mind: Art and Mathematics and Craig Harris' Leonardo Almanac: International Resources in Art, Science, and Technology, were published in the series the Press co-sponsored with its journal Leonardo and reflect the interests of the journal in the interplay of arts, science, and technology.

Among the more interesting and important books signed last year was the next book in the Leonardo series, a collection of essays and images on the impact of virtual environments. Entitled Immersed in Technology and edited by the staff of the Banff Centre for the Arts, this collection is due to be published in 1995.

At the other end of the spectrum are several important titles in theoretical computer science. Published to wide acclaim and strong initial sales was a translation of Yuri Matiyasevich's Hilbert's Tenth Problem which presents his complete solution of this famous mathematical problem. Both signed and published last year was a paperback edition of the Handbook of Theoretical Computer Science. Co-published with Elsevier, this superb collection is generating significant attention from the community and significant income.

Finally, the program made two important additions to the new Scientific and Engineering Computation Series with the user's manuals for two of the most important pieces of software for high-performance scientific computing. PVM (Parallel Virtual Machine) is the standard software for making a network of workstations behave like a massively parallel computer and MPI (Message Passing Interface) is a standard interface for addressing both these networks and stand-alone supercomputers.

**Economics and Business**

New macroeconomics and game theory books dominated this year's economics list managed by Terry Vaughn. There was also an increased presence of textbooks on the list with several key additions. Farmer: The Macroeconomics of Self-Fulfilling Prophecies an important book for the Fall of 1993 was typical of the leading edge, graduate-level book that the list has built its reputation on. At this year's gathering of the American Economic Association, Binmore: Game Theory and the Social Contract, Volume I and the long-awaited Sachs: Poland's Jump to the Market Economy drew many queries. The former is a cross of ideas from political economy and game theory by an out-spoken star from England. The latter is from the Harvard economist famous for his role as an economic advisor to Bolivia, Poland and Russia. Both are authors from whom the Press hopes for many books in the future.

One of the highlights for the economics list came in the spring, with the release of a textbook in game theory for the graduate level entitled A Course in Game Theory by Osborne and Rubinstein. Rubinstein is an extremely well-respected, young game theorist, and the textbook represents a significant addition to the presence of game theory on the list.

The spring also brought the revised edition of Paul Krugman's enormously successful trade book Age of Diminished Expectations. The book remains popular as a primer on the American economy and its sales are bolstered by the popular press coverage of the author's views.

Several books of note were signed during the year, among them four textbooks: Turnovskv/Methdods of Macroeconomic Dynamics; Poirier/Intermediate Statistics and Econometrics; Kimball and Weil/Dynamic and Stochastic Control with Applications
to Macroeconomics and Finance; and Viscusi, Vernon and Harrington/Economics of Regulation and Antitrust, Second Edition.

Long-time MIT author Jean Tirole signed on again with highly-respected Matthias Dewatripont as coauthor for The Prudential Regulation of Banks, which will appear as the first in the Press’s new Walras-Pareto Lecture series. Other upcoming economics books of note include Alesina and Roubini’s new research on political economy; Jeff Sachs’ study of China; Takatoshi Ito’s disclosure of the workings of the Bank of Japan; and Hoshi and Kashyap coverage of Japan’s financial system.

The growth of the economics program has led to the formal addition of an assistant editor. This editor will expand our publishing in areas of finance and management where interest in economic theory and business practice overlap.

MIT authors:

- Abelson & Abelson
- Adelman
- Blanchard et al.
- Borchardt
- Chivian et al., eds.
- Fay
- Fischer et al., eds.
- Hale & Keyser, eds.
- Smith & Marx, eds.
- Yoshikawa & Kauffman

Among the noteworthy books by non-MIT people from our scholarly and professional program were:

- Allen & Gale
- Barlow
- Baumol
- Binmore
- Bowker
- Campbell
- Casati & Varzi
- Clark
- Cooke
- Day
- Faugeras
- Gould
- Hill & Lloyd
- Hsu
- Kosslyn
- Koza
- Matiyasevich
- Nardi
- Rips
- Rogers
- Rosenschein & Zlotkin
- Saltë
- Schein
- Solsø
- Sterri
- Thelen & Smith
- Wiggershaus
- Williams

New hardcover books for trade and general audiences included:

- Bover
- Colomina
- Crimp
- Damisch
- Damisch
- Foster
- Holtzman
- Ingberman
- Jacobs
- Kruger
- Lerner
- McEwen
- Morris
- Robbins
- Rowe
- Sachs
- Shephard
- Silver
- Stafford
- Tschumi
- Wigley

- The City of Collective Memory
- Privacy and Publicity
- On the Museum’s Ruin
- The Origin of Perspective
- Compulsive Beauty
- Digital Mantras
- ABC
- Great Streets
- Remote Control
- Choices in Healing
- Socrates’ Ancestor
- Continuous Project Altered Daily
- Why Architects Draw
- Modernity and Housing
- Poland’s Jump to the Market Economy
- What Is Architecture?
- The Making of Beaubourg
- Artful Science
- Architecture and Disjunction
- The Architecture of Deconstruction
Books published primarily as texts included:

- Charniak, *Statistical Language Learning*
- Doets, *From Logic to Logic Programming*
- Farmer, *The Macroeconomics of Self-Fulfilling Prophecies*
- Forbus & de Kleer, *Building Problem Solvers*
- Harvey & Wright, *Simply Scheme*
- Harvey, *Time Series Models, 2d edition*
- Kaplan & Tong, *Controlling Our Reproductive Destinies*
- Martin & McIntyre, eds., *Readings in the Philosophy of Social Science*
- Pearce, *Economic Values and the Natural World*
- Person & Tabellini, eds., *Monetary and Fiscal Policy*
- Schmidt, *The Structure of Typed Programming Languages*

Editors in the Acquisitions Department include: Laurence Cohen (Philosophy, Linguistics, and Technology Studies); Roger Conover (Architecture, Design, and Art); Terry Ehling (Computational Science); Teri Mendelsohn (Philosophy); Amy Pierce (Cognitive Science); Robert Prior (Computational Science); Ann Sochi (Economics, Management); Henry and Elizabeth Stanton (Cognitive Science); Fiona Stevens (Neuroscience); Madeline Sunley (Environmental Science); and Terry Vaughn (Economics, Management).

Sales and Financial Performance

Sales in the books division were $12,530,000, about $280,000 under forecast. In fact, for the first time in the last twenty years, sales actually declined from the previous year. Despite this bad news, overall financial performance improved. We had forecast an operating deficit of -$231,000 for the year, and actually achieved a deficit of -$97,000.

Since we're now running out of general reserves because of contributions to Research Assistant/Teaching Assistant program, it seems appropriate to add a footnote in the body of this text about the financial dynamics of The MIT Press. In order to get a clear picture of the productivity of the Press's publishing operation as a business, we eliminate the RA/TA portion of the benefit pool from our operating expense line in preparing our financial statements. It is factored back in as a separate item in reconciling the bottom line and the effect on general reserves. We do this to get a true picture of the productivity of the Press's operation as compared to its sister presses (the ten largest presses in its cohort), as well as companies in the commercial publishing sector. Using these normative standards, The MIT Press generally runs at a profit and has always managed to build sufficient reserves to support continuing program development, and smooth out the business cycle and cover off years, like the current year.

By most criteria, The Press has the highest productivity level of any university press. The average benefit rate for our cohort is 27.1 percent of payroll, while ours is 38.9 percent. A more telling criteria is the relationship of salaries plus benefits to sales. The average for our cohort is about 30.4 percent. Ours is 26.4 percent. If benefits as a percentage of payroll were comparable to that of our cohort, this number would be about 24 percent. Finally, our cohort, which has a figure for average annual sales of $10.6 million (FY93), has an average staff complement of 82.1 FTE, with sales per employee of $129,000. The sales figure for FY93 at The MIT Press was $12.6 million with 71.6 FTEs and sales per employee of $179,000.

In the fiscal year just ended, our plan was to report an operating deficit of $578,000, which included a -$231,000 from the operation and a -$347,000 from RA/TA charges. In fact, we reported a net deficit of -$443,000, which included a -$97,000 from operations and a -$346,000 from RA/TA charges. The deficit will be written off against our reserve account.

While the sales in the book division were disappointing, primarily because of a high rate of return (18.7 percent compared to 16.4 percent for last year), a decline in textbook sales, the number of new titles published, and unit sales for monographs. On the plus side, we were able to cut operating costs in the last six months of the fiscal year as we noted the decline in sales coming. Cash flow was extremely good so that interest charges paid to M.I.T. were significantly lower than expected. On the other hand, investment income from the Pool C account decreased significantly because M.I.T. is now paying three percent less on our journals reserve account.

The journals division had a very good year this year, exceeding sales expectations, and reported a net of $108,000 (before RA/TA), compared to the budgeted $68,000.

In both the books and journals divisions, new programs have been launched, so that the deficits were caused primarily by reinvestment for new development.
COMPARATIVE OPERATING RESULTS (in thousands)

<table>
<thead>
<tr>
<th>Fiscal Year 1994</th>
<th>Fiscal Year 1993</th>
<th>Fiscal Year 1992</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Net Book Sales</td>
<td>$12,530</td>
<td>$12,652</td>
</tr>
<tr>
<td>Cost of Sales</td>
<td>$5,673</td>
<td>$5,704</td>
</tr>
<tr>
<td>Gross Margin on Sales</td>
<td>6,857</td>
<td>6,948</td>
</tr>
<tr>
<td>Other Pub. Income</td>
<td>189</td>
<td>218</td>
</tr>
<tr>
<td>Bookstore Net</td>
<td>103</td>
<td>120</td>
</tr>
<tr>
<td>Total Income</td>
<td>7,149</td>
<td>7,296</td>
</tr>
<tr>
<td>Operating Expense</td>
<td>7,263</td>
<td>7,186</td>
</tr>
<tr>
<td>Net Books Division</td>
<td>(214)</td>
<td>110</td>
</tr>
<tr>
<td>Journals Net</td>
<td>108</td>
<td>127</td>
</tr>
<tr>
<td>Net Pub Operations</td>
<td>(106)</td>
<td>212</td>
</tr>
<tr>
<td>Add: Investment Income</td>
<td>86</td>
<td>136</td>
</tr>
<tr>
<td>Sub: Interest Paid M.I.T.</td>
<td>(77)</td>
<td>(79)</td>
</tr>
<tr>
<td>Net Operating Gain (Loss)</td>
<td>(97)</td>
<td>269</td>
</tr>
<tr>
<td>Deduct RA/TA Contribution</td>
<td>(346)</td>
<td>(304)</td>
</tr>
<tr>
<td>Net to Reserve</td>
<td>(443)</td>
<td>(35)</td>
</tr>
</tbody>
</table>


The MIT Press management board met once during the year. Members of the board are Mr. James D. Bruce, Vice President for Information Systems and Professor of Electrical Engineering; Mr. Joseph Esposito, President, Encyclopedia Britannica Publishing Group; Ellen T. Harris, Associate Provost for the Arts and Professor of Music; Steven R. Lerman, Professor in the Civil Engineering Department; William J. Mitchell Dean, School of Architecture and Planning; Richard E. Oldenburg, Director, The Museum of Modern Art; Jerome S. Rubin, Group Vice President of Times Mirror; Jack Schulman, former Director of Cambridge University Press; Constantine B. Simonides, Vice President in the Office of the President; and Robert M. Solow, Institute Professor, Department of Economics; and Frank Urbanowski, Director of The MIT Press. Mr. Solow and Mr. Urbanowski served as ex-officio members of the management board; Constantine B. Simonides served as chairman of the board.

BOOK SALES

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Fiscal Year 1992</th>
<th>Fiscal Year 1993</th>
<th>Fiscal Year 1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>College Bookstore</td>
<td>$2,143</td>
<td>$2,281</td>
<td>$2,161</td>
</tr>
<tr>
<td>Retail Bookstore</td>
<td>2,264</td>
<td>2,557</td>
<td>2,387</td>
</tr>
<tr>
<td>Wholesaler/jobber</td>
<td>2,595</td>
<td>2,599</td>
<td>2,847</td>
</tr>
<tr>
<td>College/University Library</td>
<td>133</td>
<td>124</td>
<td>119</td>
</tr>
<tr>
<td>Direct Mail</td>
<td>662</td>
<td>548</td>
<td>522</td>
</tr>
<tr>
<td>To Individuals</td>
<td>1,219</td>
<td>942</td>
<td>893</td>
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<tr>
<td>TOTALS</td>
<td>9,016</td>
<td>9,011</td>
<td>8,929</td>
</tr>
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</table>

The decline in overall sales in the U.S. and Canada is a result of a decline in Canada; sales in the U.S. were basically flat. Unit sales overall declined to 66,047, or by 4.4 percent. International sales again, and comprised about 35 percent of our total sales, with sales to Europe through our London office increasing by about 3 percent for the year.

INTERNATIONAL SALES

In fiscal 1994, sales increases in the UK and Continental Europe and in some of the active smaller market areas such as Taiwan, Korea, Hong Kong, and Israel were set against sales declines in Australasia, Canada, and Japan. The net result was slight decline in export sales for the fiscal year.

The largest sales increase of any major market area came in the UK, where unit sales rose by almost eight percent compared to declines in the US and in total worldwide unit sales and an increase of only 3.3 percent in Continental Europe. This standout performance was almost certainly due in large part to changes in sales representation, made in the latter half of fiscal 1993, which resulted in much more focussed selling to the book trade at lower cost than previously.

Positive sales results in Taiwan and Korea were in large part due to the decline of book piracy. Although true MIT Press editions are more expensive than pirated editions, the demand for books in these countries has proven strong enough to support significant purchases even at higher prices.

Sales to Canada were especially poor this year reflecting troubles in the Canadian economy and a sharp increase in the value of the US dollar against the Canadian dollar. Textbook sales were especially affected, with net sales to college and university bookshops down by almost 39 percent.
SUBSIDIARY RIGHTS

As has been the case over the years, the core of our subsidiary rights program consists of the sale of translation rights. Although raw figures for FY94 show roughly an 11 percent decrease in this category, we had an unexpected windfall in FY93 from the sale of German language paperback rights to a single important volume. If this amount is taken into consideration, translation income in FY94 actually increased by approximately 10 percent, generated by a large number of contracts. It exceeded our projections by 38 percent. The visibility of our list abroad is high, and although most foreign houses operate under tight financial constraints, we continue to sell translation rights actively. It has been our policy to establish and to maintain active relationships with publishers abroad, and the benefits of this are obvious as new publishers entering the market in Eastern Europe approach us for rights. While publishers in Germany and Japan, where the currency is strongest, are the most active clients, we are seeing a sharp increase in the number of contracts with Chinese, Korean, and other Asian publishers.

Income from English language reprints in FY1994 remained about the same as it was in FY1993, confirming our prediction that the effects of the 1991 court order prohibiting unauthorized photocopying have peaked and stabilized. Income in this category for FY1995 should remain at approximately the same level. However, the growing interest in the licensing of electronic rights will generate additional revenue in the years to come.

The book club market was very active in FY1994, with a 39 percent increase in income since FY1993. Newbridge’s Library of Science continues to be our most active client, featuring several of our titles as main selections. This past year we saw the first sale to Quality Paperback Book Club of Book of the Month.

Subsidiary rights income in FY1994 decreased by five percent.

SUBSIDIARY RIGHTS INCOME FY1994

<table>
<thead>
<tr>
<th>Fiscal Year 1992</th>
<th>Fiscal Year 1993</th>
<th>Fiscal Year 1994</th>
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<tr>
<td>Translations</td>
<td>$141,393</td>
<td>$237,260</td>
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<td>Reprint</td>
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<td>Audio Visual</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$233,570</strong></td>
<td><strong>$381,568</strong></td>
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PROMOTION, PUBLICITY, AND DIRECT MARKETING

Direct Mail traceable sales for the year were $522,487, down 5 percent from FY93 and 21 percent from FY92. The downturn in sales can be attributed to a terrible January where sales for the month were about half of what they have been historically over the past few years. The major contributor to January sales is the Clearing Sale which was mailed on schedule, but because of the weather was slow in being delivered. Seeded names on our in-house list did not receive sale catalogs until mid-February. To compare: Direct mail income for January '93 was $62,255 with the sale contributing $35,888; income for January, 1994 was $34,013, with the clearing sale contributing $9,928. There is also the question of whether catalogs were delivered at all in other parts of the country: “Last winter thousands of pieces of mail were found burning under a Chicago viaduct, 30,000 other pieces were discovered stashed in a postal truck, 20,000 more turned up as garbage and huge piles languished in back rooms of post offices... unusually harsh weather helped push on-time delivery down to 79 percent - the lowest score since the [postal] survey began in 1991.” — The New York Times, July 12, 1994

Results for subject area catalog mailings were more promising: Economics leads as the highest income producer with sales of $75,466, followed by Computer Science/AI ($57,210), Cognitive and Brain Sciences ($42,672), Architecture ($31,718), Neuroscience ($20,422),Philosophy ($17,025), Environmental Science ($9,237), Science, Technology & Society ($8,146), and Linguistics ($7,477). Bookclearing sales from FY93 and FY94 contributed approximately 31 percent to direct mail sales for the year with an income of $164,018.

Textbook sales in FY94 were $2,260,894 for U.S. and Canada. This represents a 6.2 percent decrease over last years sales. We sold 148,109 units, an 11.5 percent decrease over last year. In the beginning of the fiscal year we processed an unusual volume of returns. These returns coupled with the decreased number of strong new textbooks had a major impact on both dollar sales and unit sales this fiscal year. New titles contributing to sales included: Farmer: Macroeconomics of Self-Fulfilling Prophecies; Goudie: The Human Impact on the Natural Environment, Fourth edition; and Lynn-Jones: The Cold War and After, Second edition in paperback. Twenty-one promotions were prepared during FY94. They were mailed to 62,457 professors in the U.S. and Canada.
Sales from the Exhibits Program were $111,000, an increase of 5.7 percent from FY93. The Society for Neuroscience held in Washington, DC was the standout meeting with sales of over $27,000 (the highest grossing meeting in the history of the MIT Press). Other meetings at which the Press had record breaking sales were the Linguistic Society of America Meeting held in Boston and the College Art Association held in New York City.

The print and broadcast media covered many MIT Press books and authors during the last year, including a record number of author interviews on National Public Radio: Jeffrey Sachs, Michael Lerner, Eric Chivian, and Paul Krugman. Details follow:

Jeffrey Sachs' *Jump to the Market Economy* was the subject of an extensive article by Jagdish Bhagwati in the New Republic, and received glowing notices in Foreign Affairs, Commonweal, the Times Literary Supplement, the Times Higher Education Supplement, the American Spectator, Academic Library Book Review, Library Journal, the Trenton Times, and the Polish-American Journal. Sachs was interviewed on NPR's "Talk of the Nation" by Ray Suarez, and the book was the subject of the New England Cable News show "Face to Face". His influential ideas reached an even wider audience through articles he wrote for the New Republic and the New York Times Sunday Op-Ed section.


Eric Chivian, author of *Critical Condition*, was interviewed on NPR's "Morning Edition," as well as by the news service Greenwire, a daily environmental briefing that goes out to environmental reporters and policymakers around the country. The book received favorable attention in Library Journal, Academic Library Book Review, Environment, and PSR Quarterly, and was mentioned in Publishers Weekly, Lancet, and the American Journal of Public Health.

Nominated by President Clinton in September of 1993 to become chairman of the National Labor Relations Board, author William Gould IV received significant media attention for his controversial stance on labor. Business Week and the Chicago Tribune published strong reviews of *Agenda for Reform*, while the Wall Street Journal and the Boston Globe discussed Gould's nomination at length.

A new wave of interest in Carole Gallagher's *American Ground Zero* resulted from the news that hundreds of Americans were exposed to radioactivity during the 50's and 60's without their consent as part of a government testing program. Carole wrote a Focus piece on nuclear testing for the Boston Globe, Fox Television's "Good Day Chicago" discussed her work, and the book received strong notices in Library Journal, the Washington Post, and the Atlantic Monthly. Credited photos appeared in the Los Angeles Times Book Review and Spin Magazine.

Simon LeVay's *The Sexual Brain* published this year in paperback, continued winning prominent media coverage. Scientific American featured an article written by Simon LeVay and Dean Hamer on the biological basis of homosexuality as part of a long, illustrated point-counterpoint piece; William Byne wrote the opposing article. The book was favorably reviewed in the Journal of Cognitive Neuroscience, and will be the feature review in a fall issue of Contemporary Psychology.


Allan Jacobs' *Great Streets* was praised in illustrated reviews in the San Francisco Examiner, Scientific American, the Architectural Review, Planning, and the Architects' Journal. It received strong notices in Publishers Weekly, Library Journal, Wilson Library Bulletin, and Architectural Record, and was highly recommended as a gift book by The Washington Times, the Chicago Tribune, the Boston Globe, the Philadelphia Inquirer, L.A. Architect, the Sacramento Bee, and Vancouver's Weekend Sun.


Publicity/Awards

MIT Press books and authors won several book awards during the last year.

*Critical Condition*, edited by Eric Chivian, received an Award of Excellence from the New England Chapter of the American Medical Writers Association.

The Society for the History of Technology chose David Nye’s *Electrifying America* for its Dexter Prize.

John Bruer received the University of Louisville’s Grawemeyer Award for his book, *Schools for Thought*. The award recognizes ideas that have the potential to bring about significant improvement in educational practice and attainment.

Joseph Kosuth, author of *Art After Philosophy and After*, was awarded The Order of Arts and Letters at the rank of Knight by France. The award is one of France’s principle decorations and honors individuals who contribute to culture in France or on an international level.

The American Sociological Association chose Donald MacKenzie’s *Inventing Accuracy* as a co-winner of the 1993 Robert K. Merton Award for distinguished work in the fields of science, knowledge, and technology.


JOURNALS

In FY 94, the Journals program had gross sales of $3.6 million, a 16% increase over last year. $120,278 was added to the deferred subscriptions reserve account, an 8.9% increase. New total reserve was $1.5 million. New journals added in FY 94 were Computing Systems, Journal of Architectural Education, and Artificial Life. Overall, the program’s net before RA/TA charges increased from $104,000 to $108,000.


FRANK URBANOWSKI
Together with the usual on-going work, much of the staff work has been focused on ways to simplify our processes; in the compensation area, the annual reviews, salary surveys, and reports; in applicant tracking; and in general reports needed both internal to the department and to other areas of the Institute.

The Department of Labor, Office of Federal Contract Compliance Programs, initiated a comprehensive review of campus and Lincoln Laboratory, hiring and promotion activity, and of the data collection supporting the activity. As a result, we were cited with a number of data collection violations. Extensive staff time has been needed to comply with the data models requested to remedy the deficiencies.

The results of the Department of Labor’s Corporate Management Review, also known as “Glass Ceiling Initiative,” have not yet been disclosed although the review took place in 1992-93.

The Faculty and Staff Information Services group, and members of the Benefits Office, have continued to explore technologies currently available in an effort to provide more efficient, concise data to the community, with an ultimate goal of electronic data access. We are fortunate to have a group of employees who exhibit enthusiasm in finding ways to improve our processes, in particular I want to commend members of the support staff, and to thank them for their caring and commitment.

Some staffing changes took place in the Personnel Office including Elizabeth Mulcahy’s transfer to the Office of Special Community Services. Marianne Howard joined the Office as Manager of Benefits. Deborah Kelley is concentrating exclusively on policy and design improvements in the Retirement Plan. Jeffrey Zeman, Benefit Counselor, has left the Benefits Office and has relocated to another state. Stephen Fairfield, Manager of Office of Special Community Services, transferred to the Leaders for Manufacturing Program. Susan Kendall temporarily came aboard to assist with special projects and has since transferred to the Office of the Chairman.

As of June 1, 1994, of the total of 28 administrative staff in the Personnel Office, 6(21%) are underrepresented minorities and 20(71%) are women. (In 1993, these figures were 6(22%) and 19(70%) of 27). In the Office of Special Community Services of the total of 3 Administrative Staff, there are no underrepresented minorities and 3(100%) are women.

As of June 1, 1994, of the total of 24 support staff in the Personnel Office, 3(13%) are underrepresented minorities and 16(67%) are women. (In 1993, these figures were 2(9%) and 17(74%) of 23). In the Office of Special Community Services the number of underrepresented minorities on the Support Staff is 1(33%) of a total of 3 and 3(100%) are women.

JOAN F. RICE

COMPENSATION OFFICE
The Compensation Office’s mission is to provide fair and equitable salary administration for the Institute’s faculty, staff, and employees. Our work is interesting and diverse, and typically involves consultation with a broad spectrum of the MIT community.

The Compensation Office’s activities are focused in the following areas: data gathering; data analysis; preparation of recommendations for annual review allocations for the Executive Committee of the Corporation; coordination and analysis of annual salary reviews; maintenance of the Institute’s classification systems, and monitoring of all payrolls for salary equity.

The Compensation Office participated in over 30 surveys, which provided the basis for developing recommendations for the Institute’s annual review allocations. We initiated nine separate salary reviews covering approximately 7,000 members of the faculty and staff, and we reviewed 75 individual requests for reclassification in the Institute’s Administrative Staff Classification System.
I wish to thank my associates Susan A. Lester, Dineen M. Doucette, and Judy K. Raymond for their initiative and teamwork in carrying out our demanding work schedule.

KERRY B. WILSON

BENEFITS OFFICE
Communications
The Benefits Office staff conducted a variety of presentations as part of a continuing effort to help members of the MIT community understand their benefit plans. Last fall, 6 one-day retirement planning seminars were offered which were attended by 202 individuals and their guests. In addition, information meetings on a variety of benefits issues and topical presentations to several departments were delivered. Forty-nine benefits orientations, attended by 358 new employees, were conducted as well as 6 benefits fairs to assist members of the community in making their open enrollment elections.

The office continues to respond to inquiries regarding enrollment, eligibility, plan provisions, including 788 requests for retirement plan estimates. The staff responded to 27,179 calls through the main telephone lines while continuing to be available for walk-ins. BenTalk received 7,110 calls for pre-recorded benefits information, form and booklet requests.

Open Enrollment
Last fall, an interactive telephone enrollment system was introduced. BenChoice received 2,978 calls; 65% of these callers recorded benefit elections, occasionally calling a second time to confirm that their elections had been recorded, while others called to listen to a summary of their current benefit choices. Using the telephone enrollment system allowed the staff to spend more time counseling individuals about their options. An estimated 100 hours of data entry time was saved by the introduction of BenChoice. The open enrollment process was improved by sending Personal Enrollment Guides to individuals with visiting appointments and individuals on leaves of absence and by including them in the telephone enrollment process to reduce the time and expense that went along with the special handling that they formerly required. Additionally, dental plan enrollment information was transmitted to the carrier electronically for the first time; and we plan to develop electronic data transfers with our health plans this year.

Educational Assistance Plans
The development of the Tuition Assistance Plan and Children’s Scholarship Plan modules of the CYBORG system were completed. These two new systems track eligibility, generate requests for payment, and maintain a history of plan payments. There were 1,811 Tuition Assistance Plan reimbursements processed and 1,388 tuition payments from the CSP were granted.

MIT Retirement Plan
Working with our colleagues from other areas of the Personnel Office, a communications program was developed to encourage greater participation in the Supplemental Savings Plan. Using feedback from a survey of 720 plan members, a campaign was developed to provide more clear and concise information about the plan. In a three month period immediately following the campaign, 341 individuals began making contributions to the Supplemental Savings Plan. We plan to develop a more aggressive campaign in the coming year.

Tax-Deferred Annuity
The Tax-Deferred Annuity (TDA) calculation system was completed. The system allows the staff to respond to participants who wish to enroll or to current enrollees who are anticipating salary or appointment status changes, generates maximum annual salary reduction limits for plan participants, and eliminates the reliance on the TDA carriers for the calculation.

MARIANNE HOWARD
FACULTY AND STAFF INFORMATION SERVICES
Faculty and Staff Information Services has the responsibility to acquire, maintain, and provide employment information about faculty, staff, and other persons affiliated with MIT and to ensure the currency, privacy, and accuracy of this information.

The office processed more than 14,000 appointments and changes. In addition, the office continues its role in the processing of salary reviews, servicing the many data requests received from within the Personnel Office and the MIT community, in responding to external employment verification requests, and producing the staff telephone directory.

The Cyborg Human Resource System was successfully upgraded from version 7.6 to version 8.2. This was a major upgrade and also the first upgrade since implementation in 1992. A minor upgrade from 1.0 to 1.36 was made to the Windows Solution application of the Cyborg System.

A considerable amount of time was spent on completing the conversion of approximately 200 computer programs. These programs produce the many reports that support the reporting function of the Personnel Office as well as the MIT community.

Implementation of a client/server-based query and reporting system was completed at the beginning of this fiscal year. Technical and user training on a query and reporting database tool called GQL was also completed for the Personnel Staff. The Department Staff now has the capability to construct reports and view information in many forms.

The Personnel Office invited the Dean’s Office of the School of Science to participate in a pilot project designed to provide direct electronic access to departmental employment data. As a first step toward this goal, the Dean’s Office successfully electronically downloaded the School’s personnel employment data from the client/server-based query and reporting system to a MAC file server.

We continue to look for ways to improve processes and to look for opportunities to automate manual tasks. As a result, there was a reduction of one support staff.

CLAIRE L. PAULDING

LABOR RELATIONS
The Office of Labor Relations is responsible for negotiating and administering the collective bargaining agreements covering approximately 1,500 MIT employees in five bargaining units. Labor Relations also represents MIT in grievance arbitrations, and in some cases, before administrative agencies in employment-related cases.

In November of 1993, the Institute signed new two-year agreements with the Service Employees International Union, Local 254 (two bargaining units, Campus and Lincoln Laboratory/Haystack Observatory) and the Research Development and Technical Employees Union (RDTEU). In May of 1994, MIT signed a new two-year agreement with the MIT Campus Police Association. All of these new agreements expire June 30, 1995. The wage increases in the agreements are consistent with MIT budgetary guidelines.

The agreement with the Security Officers’ Independent Union (SOIU), which represents the security guards at Lincoln Laboratory, expires on June 30, 1994. Negotiations for successor agreements began in May and continue as of the date of writing.

The number of grievances filed fell in comparison with the prior year. Three grievance arbitrations were held. The award in one was in favor of the Institute, one was settled prior to completion of the hearing, and one is on-going. Seven grievances have been filed to arbitration and have yet to be heard. Four charges were filed against MIT with the National Labor Relations Board (NLRB). One charge was dismissed (the dismissal has been appealed, however), in one charge a complaint was issued and a date set for a full evidentiary hearing of the merits, and two have not yet been considered by the NLRB.

DAVID B. ACHENBACH
EMPLOYMENT
In the past year, the Employment Group has been working on further enhancements to the RESTRAC applicant tracking system, including the development of an electronic applicant referral system, use of merge programs to generate letters and mailing labels, and the installation of "kiosk" workstations in the reception area to allow job candidates to enter application data directly into the system. The system has also been a great tool in generating numerous reports on applicant and new hire activity for purposes of MIT internal tracking and Department of Labor review. We also moved forward in the use of another application of the new system--an on-line resume pooling and candidate search program. This program allows Personnel Office staff to "query" a database of over 3000 selected candidates to determine if there is a suitable match for available positions (based on specified job qualifications). Our hope is that this new program will help alleviate advertising costs and administrative time in recruitment efforts while moving us further toward a paperless form of applicant information processing.

During the past year, approximately 13,000 applications were received and processed in the Personnel Office. Approximately 725 persons were hired into non-faculty positions that were listed with the Personnel Office, of which 204 were MIT internal applicants who were seeking employment alternatives due to layoff or other circumstances.

Approximately 700 unemployment claims were processed this year for former employees on campus and Lincoln Laboratory. Several staff members worked to develop material for employees receiving layoff notices which included information about employment alternatives within and outside of MIT, agencies assisting in employment searches, and state unemployment benefit and retraining programs.

In February of this year, two programs on employment advertising and recruitment resources for MIT administrative officers and personnel administrators were given, co-led by members of the Employment Group and representatives of our advertising agency, JWG Associates. The programs highlighted current resources for special recruitment efforts (such as for affirmative action recruitment and introduced hiring managers to the resume pooling feature of the RESTRAC system.

Also this year, we continued our work with the Cambridge Teen Work Program to help develop training and employment opportunities at MIT for local high school students. In addition, we made further contacts with such organizations as the Massachusetts Department of Employment and Training, Greater Boston Rehabilitation Services, Massachusetts Commission for the Blind, and Operation Transition (a reemployment assistance service for US Military personnel) to increase efforts to identify qualified job candidates in the community and to further MIT efforts towards affirmative action and increased diversity in its staff.

CYNTHIA VALLINO

PERSONNEL SERVICES
The primary mission of the seven Personnel Officers is to provide a full-range of employee relations services to both employees and supervisors within the various organizational units. These include staffing assistance, job counseling, policy interpretation, performance evaluation, salary administration, and conflict resolution.

Due to MIT's focus this year on reengineering, Personnel Officers have spent a greater amount of time on conflict resolution and have worked hard to provide specific guidance to those employees who were particularly anxious about their employment status. Their expertise has been sought by the Performance Evaluation Review Committee for Administrative Staff reporting to the Senior Vice President and by the Committee which produced the new guide, Dealing with Harassment at MIT. They also participated in workshops focusing on layoff guidelines and support systems, the performance evaluation process, and sexual harassment procedures coordinated by the Administrative Advisory Committee.

In conjunction with a Department of Labor audit this year, Personnel Officers have begun to work more closely with Senior Officers and supervisors as schools and departments establish new affirmative action goals for 1994-95. In addition, they have found RESTRAC (the new applicant tracking system) an important tool in getting faster applicant response from the departments and in obtaining more sophisticated employment reports as necessary.

SALLY H. HANSEN
TRAINING AND DEVELOPMENT PROGRAMS
Over 1,400 MIT employees attended programs offered through this office since the fall. Topics ranged from the implementation of personnel principles, to supervisory skills, to listening skills, to scientific and technical writing, to internal customer service, to managing conflict.

In September, the Personnel Office distributed its booklet offering training and development programs to MIT’s employees. The response for these courses was so great that they were repeated during the spring semester to serve those on the waiting lists.

In addition, a number of departments and laboratories requested customized programs on such topics as diversity, harassment awareness, conflict resolution, situational leadership, and communication skills.

Several other groups sponsored programs with the assistance of this office, including the Administrative Advisory Committee and the Working Group on Support Staff Issues. Topics included management styles, performance appraisals, and communicating upward.

Design and development assistance was provided to the Associate Provost for Institute Life for programs on complaint handling of harassment cases. These programs were designed for those in supervisory roles.

MARGARET ANN GRAY

OFFICE OF SPECIAL COMMUNITY SERVICES
The Family Resource Center
Services offered by the Family Resource Center this year included approximately 900 office consultations, 35 workshops, 4 courses, 30 briefings, and 6 support groups on topics related to balancing work and family, child care, schooling, and parenting. Office consultations were attended by approximately 1,000 MIT students, faculty, staff, and family members; and workshops and groups by an additional 850.

Briefings and workshops were expanded to include a greater variety of topics and formats and several were offered to individual departments on request. The Center’s lending library added approximately 300 new volumes, largely thanks to donations from members of the MIT community.

In May, the Family Resource Center, with support from several MIT departments and with the co-sponsorship of the MIT Medical Department’s Breastfeeding Support Program, opened the MIT Nursing Mothers’ Room adjacent to the Women’s Lounge in Room 10-384.

J. B. Sweeney, the Center’s Senior Office Assistant for four years, resigned in January and was replaced by Lynn Sweezy.

KATHY SIMONS, RAE SIMPSON

The MIT Activities Committee (MITAC), established in 1983, continues to serve the cultural and recreational needs of the MIT and Lincoln Laboratory communities, their families, and friends. MITAC organized 59 events, attended by over 4,000 members of the MIT community. Over 1,200 discount coupon books were sold and more than 22,000 discount tickets (movie and other) were sold from the MITAC offices on campus and at Lincoln Laboratory. In September 1993, Barbara Gilligan replaced Diane Betz Tavitian as Administrative Assistant and assumed the responsibilities of managing and administrating the day-to-day operations of the MITAC Office. Effective July 1, 1993, Carrie Young was appointed Senior Office Assistant on a part-time basis to serve as the MITAC representative for the Lincoln Laboratory community.
The MIT Quarter Century Club has over 2,500 members, made up of employees, retirees, and honorary members. The Club’s annual picnic was held on August 10, 1993, in the Johnson Athletic Center. Over 700 members and guests were present and feasted on traditional picnic fare and were entertained by Jay Keyser and the Intermission Plus jazz group. Approximately 85 women gathered for the Silver Club High Tea on October 5, 1993, at the MIT Faculty Club. The annual Holiday Gathering was held in the Sala de Puerto Rico of the Stratton Student Center on December 7, 1993, and was attended by over 400 Club members. At a luncheon held at the MIT Faculty Club on March 22, 1994, 127 new members were inducted into the Club. James Fandel, President of the Club, opened the program and Charles M. Vest, President, and Constantine B. Simonides, Vice President and Secretary of the MIT Corporation, spoke to the group, thanking them on behalf of MIT for their years of service and contributions over the years.

The 15-member Board of Directors is led by President and Acting Chair, James J. Fandel. Other officers of the Quarter Century Club are: Francis B. Magurn, Vice President; Winifred T. McDonough, Treasurer; and Mary Frances Daly, Secretary. Current directors are Dorothy L. Bowe, Richard J. Cerrato, James W. Coleman, Kenneth V. Donaghey (installed September 30, 1993), Anthony P. French, Kenneth L. Hewitt, Barbara A. Johnson, George F. Koster, Salvatore Lauricella, Walter L. Milne, and Carol Ann Tranfaglia. A luncheon meeting of the board was held at the MIT Faculty Club on April 19, 1994, to honor Professors J. Francis Reintjes and Henry J. Zimmermann on their retirement from the Board.

The 1993 United Way Campaign reached over 98% of its goal of $320,000. There were a total of 1,724 contributions totaling $314,980.42. The single largest donation was $10,000, and the average donation was $182.70. The percent of community members that gave increased 8% from the previous year. The number of Leadership Givers that gave $1,000 or more increased from 54 to 60.

The OSCS provides staff support and office space to the MIT-Cambridge Chapter #2893 of the American Association of Retired Persons (AARP). The Chapter, chartered since 1978, has a total membership of 182 and is led by six officers and an 18-member board. The Board meets quarterly to organize seven chapter meetings and sponsor several leisure excursions each year.

The Annual Retirement Dinner was held in Morss Hall, Walker Memorial, on Tuesday, May 31, 1994. Hosted by President Charles M. Vest and Mrs. Rebecca M. Vest, it was attended by 210 guests, including retiring employees, their guests, supervisors, Quarter Century Club Board members, and other senior MIT administration. Throughout the dinner the names of each of the 155 retirees were read by Rebecca M. Vest, Mark S. Wrighton, Provost; Richard J. Cerrato, Dorothy L. Bowe, and Walter L. Milne, Quarter Century Club Directors; and William R. Dickson, Senior Vice President, who also served as master of ceremonies for the event.

Staff changes in OSCS included the transfer of the following individuals to other MIT departments: Stephen A. Fairfield, Manager, OSCS; Susan L. Kendall, Administrator; and Diane Betz Tavitian, Administrative Assistant. New and/or changes of appointment in OSCS included the following: Elizabeth K. Mulcahy, Administrator; Barbara Y. Gilligan, Administrative Assistant; Debra S. Fair, Senior Staff Assistant; and Carrie J. Young, Senior Staff Assistant.

ELIZABETH K. MULCAHY
Public Relations Services

This past year, the staff in Public Relations Services worked together to clarify the purpose of various services, including specific publications or procedures, to better serve the needs of people inside and outside the Institute, and to increase the accessibility of information about MIT programs, issues, and activities. In some cases, reevaluation of mission led to redesign of a publication or process, as with the redesign of the catalogue. The innovations were not only in the design, but in the way in which people across the Institute were brought together to evaluate and improve this key source of academic information.

The year has witnessed continued enhancement of computer and other electronic resources, leading to greater control over production, better communication with vendors and clients, increased efficiency, and improved management. These developments extended beyond campus communication toward wider communication with the world at large. For example, the News Office expanded its outreach through electronic distribution of science news releases.

In the coming year, we will continue to explore new publishing technologies and work to provide better communications links with those we serve and those whose services we seek.

The quality of service in all of these areas is made possible by the extraordinary energy, creativity, and team spirit displayed by the people who work in Public Relations Services. Their sense of service and loyalty to MIT is imbued with Constantine's spirit.

KATHRYN A. WILLMORE

COMMUNICATIONS OFFICE

The Communications Office produces the Institute's annual reference publications, including two issues of the MIT Bulletin; Reports to the President; Reports of the Treasurer; and the Faculty and Staff and Student directories. Additional publications such as the Report of the President appear as Tech Talk supplements. The office strives to increase accessibility of information by continuously improving both content and format of its publications.

The Communications Office accomplished its three goals set last year. With the assistance of Stephen Scarano, Assistant to the Vice President, for Information Systems, the office planned and implemented its migration to a new computer environment. Now, three networked Macintosh computers support the office's production work. Electronic mail and MITnet links have already changed how the office communicates with its information providers, and a broader array of software packages enables the office to anticipate greater efficiencies in future production cycles.

Second, the Communications Office worked closely with Admissions and the Registrar to define the mission of the MIT Bulletin in the context of other Institute publications. Working together for several months, the group defined the essential purposes to be served by the course catalogue and, based on those principles, clarified the mission and audience for the publication. This clarification makes it easier to evaluate the extent to which information is accurate, accessible to and useful for key customers, and helps eliminate redundancies in information distributed to current students and prospective applicants. During this same time, the office worked closely with Design Services to redesign the catalogue to fulfill its purposes more effectively.

Third, the office supported the Institute's efforts to apply the principles and methods of total quality management with staff representation on two working committees sponsored by Senior Vice President William Dickson: the Publication Services Review Group and the Mail
Committee. Throughout the year, the office's manager continued to serve on Vice President Simonides' Working Group on Quality Management at MIT.

The Communications Office has identified three major goals for next year: The office will:

- Evaluate the extent to which the course catalogue succeeds in providing information that is accurate, accessible, and useful by surveying a sample of key catalogue customers.

- With colleagues, explore the ramifications of electronic publishing on the worldwide web by comparing the production of hard copy and electronic versions of the same document, and publishing results in a case study.

- Continue to improve business processes in the office by employing features of new software for publishing, database design, and spreadsheet applications.

**Personnel**

In one short intense year, the Communications Office transformed its technology infrastructure and planned and implemented a redesign of the course catalogue — an enormous effort that succeeded because of patient, dedicated teamwork. Members of the team, who have worked together for four years, include manager Barrie Gleason, editor and production manager Ruth T. Davis, and administrative assistant Marianne Charny.

BARRIE GLEASON

**OFFICE OF DESIGN SERVICES**

The Office of Design Services produces approximately 300 graphic design and publishing projects a year. These include recruitment material for the five academic schools, as well as publications for the Corporation, Resource Development, Public Relations Services, the Medical Department, the Media Lab, the Office of the Arts, and the MIT Museum. The scope of design work includes brochures, posters, catalogues, booklets, newsletters, identity programs, and coordinated packages for MIT special events such as conferences. The mission of the Office is to bring the highest standards of graphic design into the creation of visual material that will enhance their effectiveness, as well as to provide high-quality electronic publishing services for the MIT community.

Among the publication highlights of this year were materials prepared for the Biology Building Dedication, the Media Lab Digital Expression Symposium, and the Quality of Thinking Conference; the Civil Engineering Department brochure; the Guide for Dealing with Harassment at MIT; the MIT Briefing Book; and the re-design of the *MIT Bulletin*. In the area of improved operations, Design Services continued efforts to upgrade publications by providing publishing services which significantly refined the design and production management of office work. Recent improvements to our electronic system included better equipment for our staff, as well as upgrades of computer software, and a shared-access office network. In addition, we provided design templates for Institute clients, and continued to distribute a survey in an effort to evaluate how we can better serve our customers and provide more effective MIT communications.

Among the goals for the coming year are the following:

- actively expand our accessibility to major Institute clients;

- establish stronger communication links between internal offices;
continue to upgrade publications and explore new publishing technologies that will create more efficient methods for typesetting, printing, and office bookkeeping;

work on internal staff development and education that will streamline office systems and make publications more cost-effective; and

explore and improve procedures for generating income.

**Personnel**

I would like to thank my staff members, Elizabeth Chimento, Anne Hubbard, Lee Corbett, and Elizabeth Ferry for their outstanding contributions and enthusiastic support. It is a pleasure to work with a group that always remains open to new challenges and new ideas.

**CELIA METCALF**

**INFORMATION CENTER**

The mission of the Information Center is fourfold: to meet the informational needs of the MIT community, visitors to the campus, and the public; to promote a sense of community within MIT; to support conferences and events which enhance MIT's role in the broader academic community; and to support MIT's international community of scholars.

**Information Center and Special Events**

During the past year, the Center again served as a clearinghouse for mail addressed to MIT; maintained the official Institute mailing lists; answered and directed to other offices telephone and office inquiries from the public and MIT community; distributed over 40,000 pamphlets, brochures, maps, guides, and catalogues; and maintained records and published a *Tech Talk* supplement describing and listing memberships of faculty and presidential committees. The tour guide captain Michele M. Chomiszak, Class of 1994, worked closely with Terri Priest, staff associate in the Information Center, who trained and scheduled 27 guides who conducted tours for 11,000 visitors; of these visitors, 3,800 were prospective students, 1,600 international visitors, and the remaining guests visiting MIT. Assisting during the summer as full-time guides were Jeannette Kae, Class of 1994, and Christine Lim, Class of 1996.

Kathleen Barrett, staff associate, continued to serve the Center and oversee the many detailed tasks that are part of the operation. Her knowledge, history, and general goodwill are a positive public relations asset for MIT.

Ms. Priest organized and skillfully arranged nearly 500 short-term international visitor programs. Short-term international visitors are sponsored by the United States government and include distinguished leaders in a variety of fields, such as heads of government and cabinet members, who are selected by their countries to visit the United States. The program promotes international communication and peace. These visitors do not include international visitors who take general tours of the Institute.

Donald Ferland assisted the director in coordinating special events that included the 80th birthday celebration for Kay Stratton, the Edgerton Center celebration, and – the saddest of all – the memorial service for our leader and good friend of many years, Constantine B. Simonides. It was a labor of love and a final salute to a man who encouraged, promoted, and engineered leadership qualities for many of us. Although our loss is great, his *joie de vivre* and vitality will always remain.

At the close of the academic year, the Hooding Ceremony for doctoral degree recipients, held the evening before Commencement, was an event of celebration and joy for the graduates, their
families and friends, and faculty. The Commencement Exercises held in Killian Court featured a thoughtful speech by his Highness Prince Karim Aga Khan IV, spiritual leader of the Shia Ismaili Muslims, in which he said the world must be prepared to draw upon the wisdom of the ex-Communist world, the Muslim world, and the Western world in solving the problems of modern society.

Conference Services
The Conference Services Office manages the logistical arrangements of conferences and meetings sponsored by MIT faculty and staff, ranging in size from 10 to 2,000. This past year, the Office coordinated 25 such events, which brought more than 8,000 visitors from all over the world to campus, including the National Association of Enrolled Agents, International Conference on Dynamical Processes, Diagnostic Pathology ’93, Geoplasma Physics Workshop, Society of Rheology Annual Meeting, International Symposium on Fusion Engineering, Society of Literature and Science Annual Conference, first Black Women in the Academy Conference, Campus Law Enforcement Meeting, 1993 Convocation of the Episcopal Diocese, New England Conference on Technology and Education, Massachusetts Biotechnology Council Symposium and Trade Exposition, National Council of Acoustical Consultants, Interactive Media Workshop, 127th Meeting of the Acoustical Society of America, Symposium on Quantization and Nonlinear Wave Equations, and Massachusetts Special Olympics Summer Games.

The Office assisted with the logistical management and registration in conjunction with the Industry Summit held on campus in September, which was co-hosted by the World Economic Forum and MIT in cooperation with Harvard University. In addition, the Office worked with MIT’s Program in Technology, Management, and Policy on the arrangement of two summer courses, and assisted the Office of Laboratory Supplies with their second annual Vendor Trade Show which brought over 125 vendors to campus.

This Office handled the arrangements for more than 110 recruitment presentations by companies and other organizations that visited MIT under the auspices of the Office of Career Services and Preprofessional Advising.

Marie Seamon, assistant coordinator, and Patricia Ezekiel, administrative secretary, once again provided invaluable assistance to the manager on all these events.

International Scholars Office
This Office served a total of 1,381 scholars which included: 1,086 J-1 exchange visitors, including 37 Fulbright Scholars; 151 H-1B professionals in specialty occupations; 198 scholars in other visa categories; and 29 applications were filed for permanent resident status.

Regulations and procedures for the H-1B visa classification are in a state of flux. MIT’s ability to hire the most qualified researchers and teachers is threatened by pending regulations. Dana Bresee Keeth continues to be in close touch with the MIT Washington Office and Government Relations Office at MIT to brief them on these issues and to share the perspective of NAFSA, an association of international educators. Dana has joined with other universities to successfully persuade members of Congress to halt implementation of the General Agreement on Trade in Services (GATS) provisions which would have limited MIT’s use of this visa classification. We continue to support efforts to persuade the Immigration and Naturalization Service and the Department of Labor to designate a category of the H-1B for academic use only.

Procedures to implement the mandatory health insurance requirement for all J exchange visitor visa holders have been worked out with the MIT Insurance and Legal Affairs Office and Medical Benefits Office. Information has been sent to all academic and administrative officers concerned with scholar matters to inform them of the health insurance requirement which goes into effect September 1, 1994.
Frances Helmstadter, as the Government Regulations Representative for the New England area, has direct contact with immigration officers in district and regional offices and with other agency personnel in informing them about procedural changes.

The staff has been involved in the revision and inclusion of immigration documents on Tech Info; presented workshops at the NAFSA regional conferences; met with the Academic Staff Appointment Process Group to improve processing and information sharing on hiring foreign nationals; and continued its review of computer records and reports for accuracy and completeness.

Among the goals for the coming year are the following:

- close monitoring of changes in immigration regulations and procedures, particularly the H-1B visa category;
- monitoring implementation of the health insurance requirement for J exchange visitors;
- assisting in the definition and implementation of a new student category at MIT, called "visiting student," for students who are registered at other universities and come to MIT to work with faculty for a brief period of time;
- improving access to Tech Info and electronic requisitioning; and
- issuing a report on international scholars on an annual basis.

**Personnel**

The year marked a happy event when Dana Bresee Keeth gave birth to Graham Robert. While Dana took a three-month maternity leave, Jennifer Stevens, a colleague and friend of this office and former Director of the Harvard International Office, assisted the International Scholars Office in processing H-1B visas.

Gayle Fitzgerald received the much deserved promotion to associate director of Special Events and the Information Center, while maintaining her responsibilities as manager of Conference Services.

A special salute to all members of the Information Center, Conference Services Office, and International Scholars Office without whose caring and team effort all of the above would not be possible.

MARY L. MORRISSEY

**NEWS OFFICE**

Among the news highlights of the past year were the following: Professor of Biology Phillip A. Sharp’s winning the Nobel Prize; MIT’s successful settlement of the financial aid antitrust case with the U.S. Justice Department; *US News and World Report* assessment of MIT as the #1 graduate engineering school, the #2 graduate management school, and the #4 university in the nation; MIT scientists being part of team that announced the first direct evidence for the top quark.

The year started with President Clinton appointing MIT Associate Provost Sheila Widnall to be Secretary of the Air Force, the first woman to head one of the armed services. At the end of July, Professor Glen Urban was named the new dean of the MIT Sloan School of Management, an appointment that was well received in *The New York Times, The Wall Street Journal, The Boston Globe,* and *The Boston Herald.*
On September 17 came the news from Philadelphia: The three-judge appeals court unanimously reversed the summary decision of the lower court, saying that overlap may enhance competition and that it required a "rule of reason" trial. One judge found unequivocally for MIT, saying that "the antitrust laws do not apply to student aid activities in the circumstances of this case." The News Office in early October launched a major campaign for editorial support, sending packets of information to more than 100 editorial page editors. The campaign generated 20 editorials in the last four months of 1993, including three from The New York Times, two from The Washington Post, and individual editorials from newspapers including USA Today, The Boston Globe, The Boston Herald, the Sacramento Bee, and the Fresno Bee, the Sarasota Herald Tribune, the Providence Journal, and the Quincy Patriot Ledger, as well as smaller papers throughout the country. On December 22, the Justice Department agreed to dismiss the antitrust case against MIT and establish a new way for nonprofit colleges to cooperate on need-based financial aid to undergraduates.

On Columbus Day came the dawn's joyous news of Phillip Sharp's Nobel Prize in Physiology and Medicine for his discovery that genes are "split" or present in distinct segments separated by other "nonsense" segments. MIT experiments about life in space flew on the Space Shuttle in October. In late October, the groundbreaking for the new, $2 million shelter MIT had pledged to build for the Cambridge and Somerville Program for Alcohol Rehabilitation (CASPAR) symbolized a new era in relations between MIT and Cambridge. The shelter was formally opened on June 6.

Professor Richard Wurtman's discovery that a small dose of melatonin, a hormone associated with night sleep, can act as a sedative during daylight hours, created much interest in the media in November. On November 24, British author Salman Rushdie paid a surprise visit to MIT to read his works and accept an honorary visiting professorship.

On November 30, President Charles Vest, Provost Mark Wrighton, and Senior Vice President William Dickson held a town meeting at the Student Center to discuss MIT's need to trim $40 million from its budget over the next three years. In March, MIT started a reengineering effort to examine fundamentally the way work is done in administrative offices to see if major economies can be achieved. Kathleen Rowe of the News Office was a member of the Reengineering Core Team, headed by Vice President James D. Bruce.

On December 26, The Boston Globe reported that MIT and Harvard scientists in the 1940s and 1950s had used mildly radioactive tracers to study the metabolism of iron and calcium in cereal at the Fernald School for retarded children in Waltham. The work had been published in the scientific literature at the time. Although a commission which studied the situation for several months agreed with MIT's position that there were no adverse health effects from the situation, the scientists and the state doctors in charge of the school were criticized for the apparent lack of informed consent from the patients or their guardians for the medical research. An MIT "Primer on Radiation," showing the permissible levels, was incorporated into the state's final report.

MIT was host to the "Black Women in the Academy" conference in January, which the Chronicle of Higher Education featured on its front page and called "the event of the century" for black women. In February, Coretta Scott King was the principal speaker at MIT's 20th annual celebration of the life and legacy of Dr. Martin Luther King, Jr.

In March, MIT experiments on how structures vibrate in space drew press attention for the Space Shuttle Columbia's flight. The invention of a dimpled bat, on the same aerodynamic principle as the dimpled golf ball, drew much press attention. MIT and Amgen, a leading biotechnology company, announced a long-term research collaboration to pursue joint research initiatives.
Tech Talk, News Releases, Research Digest

Internally, *Tech Talk* was published 37 times, under the editorship of Joanne Miller, assisted by Alice Waugh. Special issues featured the Industry Summit and the MIT budget problems.

Elizabeth Thomson of the News Office began to distribute science news releases on the Internet. The News Office issued 160 news releases. The very successful two-sided, illustrated MIT Research Digest entered its third year of monthly publication, a cooperative venture of writers Charlie Ball and Elizabeth Thomson, with editorial and design support from Lisa Damtoft.

Personnel

The News Office staff during the year includes Kenneth D. Campbell, director; Robert C. Dilorio, associate director (who also serves as managing editor for science and engineering news); Charles H. Ball, senior assistant director; Donna M. Coveney, assistant director/photojournalist; Myles P. Crowley, administrative assistant; Lisa Damtoft, editorial and design assistant; Joanne Miller, assistant director and editor of *Tech Talk*; Kathleen M. Rowe, assistant director, media relations; Elizabeth Thomson, assistant director for science and engineering news; Alice C. Waugh, assistant editor/staff writer, who joined the News Office in July, 1993; and Chandra Wilds, receptionist.

Softball

As of July 7, the Clippers, managed by Lisa Damtoft and strengthened by friends from various departments, have scored between 2 and 49 runs in games thus far and have a 2-3 record.

KENNETH D. CAMPBELL
The result of financial operations for the Fiscal Year 1994, which ended on June 30, 1994, was a deficit of $6.2 million after using all unrestricted gifts and income received and undesignated either by donor or by senior Institute officials. The Fiscal 1994 budget approved by the Executive Committee in May 1993 included a deficit of $10.3 million. The forecast of the deficit as of May 1994 was $14.1 million with some anticipation that favorable financial results in a number of areas might result in a lower deficit. At financial closing, the actual deficit was $6.2 million, the decrease due primarily to unexpended funds in the academic and support areas.

MIT had modest surpluses in the operating budget in Fiscal 1984-1988, and modest deficits in Fiscal 1989-1994. The deficit in Fiscal 1993 was $10.1 million and, as mentioned above, we have a deficit of $6.2 million for Fiscal 1994. Our current projections are deficits of $8.9 million for Fiscal 1995, $1.1 million for Fiscal 1996 and a surplus of $2.7 million in Fiscal 1997, if our Reengineering efforts are successful.

It is important to note that MIT is a financially strong institution with its nearly $2 billion endowment and occupies a leading position in science and technology education and research. MIT remains an attractive place for scholarship and learning by outstanding students, faculty and research staff.

To continue to be financially sound, however, we must continue to maintain balance in the operating budget through judicial and well-planned implementation of cost containment measures, including Reengineering efforts, and continued rigorous budget control exercised by the President, Provost and other Senior Officers for the areas in which they have management responsibility.

Reengineering efforts must succeed, and succeed in a manner unique to MIT. As stated by President Vest, "We must take the lead in the higher education community to show how change in the service of education and research can be accomplished. If we do not succeed in this, we will not succeed in regaining the public trust as the social contract between universities and the nation is rewritten for a new era. Now many worry that Reengineering can succeed only by paying the price of destroying institutional value and community. This is simply wrong. The contrary is the case. No matter how we reorganize and change, it will still be the values, loyalty, and commitment of people that will make MIT great in the future, just as in the past."

A large portion of the burden in our Reengineering and cost control measures rests with the people in the Financial Operations area. Again this year the events in the area of audit and financial review have necessitated efforts by many members of Financial Operations well beyond their normal responsibilities, while taking on significant responsibilities in staffing the committees of Reengineering. These extra efforts are very much appreciated by all members of the MIT community.

The reports of each department highlight the major activity that has occurred during the year. While they describe many of the activities, they cannot adequately express the amount of care and effort of Financial Operations staff to ensure that the finances of MIT continue to be effectively managed. I extend my sincere appreciation to all members of Financial Operations for their outstanding efforts.

This will be my last report as the Vice President for Financial Operations as I assume new responsibilities as the Vice President for Administration. I want to sincerely thank all of my colleagues in Financial Operations who have made the ten years that I have been responsible for Financial Operations the most interesting and professionally rewarding years of my career. My predecessor, Stuart Cowen, who we unfortunately lost this year, bequeathed me a strong cadre of competent professionals when I took over as Vice President. This cadre of professionals, and how effectively they operate, have made the job of Vice President an easy one, even during the difficult times of budget imbalance and regulatory assaults in all areas. I have learned a great deal from my interactions within Financial Operations and I thank all of those who provided me such great support during my tenure. My highest regard goes to the professionals in each of the areas, and particularly to those who have led these efforts so well, and become very close friends as well as colleagues, specifically, Jack Currie, George Dummer, Jack Frailey, Phil Keohan, Barry Rowe, and Chuck Shaw. The change for me is bitter-sweet, as I look forward to my new responsibilities, but will miss very much my daily contact with the people in Financial Operations.

I cannot close without mentioning how much I will miss the personal friendship and professional rapport of Constantine Simonides, whose sudden death this spring has left a vacuum at MIT that is impossible to fill. Constantine has been a source of strength and guidance for me throughout the almost twenty-five years that I have been at MIT. I thank him for his constant care and attention to his "brother" in Financial Operations. I will miss him greatly.

AFFIRMATIVE ACTION EFFORTS IN THE FINANCIAL OPERATIONS AREA

Increasing the numbers of women and minorities in career positions continues to be a major goal of the area. Every search plan and appointment to the Administrative Staff is reviewed by the five area departments heads, with final approval, on their advice and consent, by the Vice President. This procedure has been effective in keeping affirmative action efforts a priority on a weekly basis and has had good results in the hiring and promotion of women and minorities. These efforts continue as a major priority of the area.
As of June 30, 1994, the total number of women administrative staff is 105 (44%) while underrepresented minorities are 23 (10%) of the Administrative Staff of 237. (In 1993, these figures were 108 (45%) and 21 (9%) of 241, respectively.)

Including support and service staff members, the number of underrepresented minorities is 48 (12%) of a total staff of 411. (In 1993, the figure was 50 (12%) of 421.)

A statistical analysis of affirmative action results follows for each major area of Financial Operations.

**Audit Division**
The number of women administrative staff members is 3 (33%) out of a total administrative staff of 9. (In 1993, the figure was 3 (33%) out of a total of 9.)

The number of underrepresented minorities is 2 (17%) out of a total staff of 12. (In 1993, the figure was 1 (8%) out of 12.)

**Comptroller**
Comptroller's Accounting Office, Lincoln Laboratory Fiscal Office, and Property Office

The number of women administrative staff members is 43 (37%) out of a total administrative staff of 108. (In 1993, the figure was 43 (38%) out of a total of 113.)

The number of underrepresented minorities is 16 (8%) out of a total staff of 193. (In 1993, the figure was 15 (7%) out of 202.)

**Office of Financial Planning and Management**
The number of women administrative staff members is 5 (38%) out of a total administrative staff of 13. (In 1993, the figure was 5 (38%) out of 13.)

The number of underrepresented minorities is 2 (14%) out of a total staff of 14. (In 1993, the figure was 2 (14%) out of 14.)

**Office of Purchasing and Stores**
The number of women administrative staff members is 11 (37%) out of a total administrative staff of 30. (In 1993 the figure was 10 (33%) out of 30.)

The number of underrepresented minorities is 11 (15%) out of a total staff of 72. (In 1993, the figure was 11 (15%) out of 73.)

**Office of Registration and Student Financial Services**
The number of women administrative staff members is 35 (75%) out of a total administrative staff of 47. (In 1993, the figure was 39 (78%) out of 50.)

The number of underrepresented minorities is 16 (21%) out of a total staff of 77. (In 1993, the figure was 18 (22%) out of 82.)

**Office of Sponsored Programs**
The number of women administrative staff members is 7 (39%) out of a total administrative staff of 18. (In 1993, the figure was 7 (39%) out of 18.)

The number of underrepresented minorities is 2 (7%) out of a total staff of 28. (In 1993, the figure was 3 (10%) out of 29.)

JAMES J. CULLITON
While the Audit Division's focus adjusts to the changing needs of the Institute, our role remains essentially unchanged as we continue to serve the Institute in accordance with the stated mission of providing reasonable assurance to management that an adequate internal control structure is maintained, policies are being adhered to as intended, and assets are properly safeguarded. We accomplish this through reviews, both on campus and at Lincoln Laboratory, which encompass diverse aspects of MIT operations.

Our audit coverage is coordinated with Coopers & Lybrand, the Institute's Certified Public Accounting firm, and the Defense Contract Audit Agency (DCAA), MIT's cognizant federal audit agency. Internal audits are conducted consistent with the Standards for the Professional Practice of Internal Auditing which guide us in the discharge of our duties to ensure proper objectivity, independence and audit quality control.

This year looks to be a particularly challenging one for all of MIT as we face a continued budget shortfall. Reengineering of major administrative processes requires strong commitment throughout the Institute and substantial Audit Division involvement in helping MIT maintain a strong internal control structure before, during and after reengineering.

Departmental Reviews have been a staple of our audit plans for several years. These fundamental compliance audits help to ensure proper financial accountability within each department, center and laboratory. Many Institute guidelines and policies mirror expectations of Federal sponsors for responsible trusteeship of funds. This year's planned departmental review coverage will mark the completion of our second Institute-wide departmental review cycle.

Evaluations of financial accountability and controls have also been an important area of Audit Division involvement over the past year. In particular, cash control issues were prevalent within many audits recently conducted and will continue to be addressed in several upcoming reviews. Audit Division analysis of consultant use, bank account controls, and recharge practices by internal service providers are currently in progress.

Involvement in the Institute's administrative information systems is another major segment of Audit Division effort. We continue to support endeavors to increase use of electronic records; contribute to the Institute's Continuity Planning effort to ensure timely recovery from potential business interruption; and remain involved with administrative computing resource management and information security. With such active growth of information technology, especially telecommunication networks, the Audit Division's attempts to address security and control concerns are a growing challenge. Our new audit approach allows each auditor to gain a baseline understanding of several computer based information systems and maintain ongoing contact with key individuals in various administrative areas. This will better equip us with an up-to-date broadened knowledge of MIT's information systems' risks and help us better prioritize audit coverage.

This past year, three members of the Audit Division staff completed examination requirements for professional certification. It is expected that all audit staff will pursue professional certification as a CPA, CIA (Certified Internal Auditor), or CISA (Certified Information Systems Auditor). Collectively, the Audit Division now holds 2 CPA, 5 CIA, and 3 CISA designations.

CHARLES A. SHAW
THE COMPTROLLER'S ACCOUNTING OFFICE-CAMBRIDGE

Payroll

The project to shift the processing of Graduate Fellowships and Postdoctoral Fellowships from the Accounts Payable System to the Payroll System to more efficiently comply with tax withholding and increased reporting requirements was completed. The project to transfer employee bank deposits via secured telephone link to BayBank was also completed and will provide a better and faster process for delivering such data, particularly during holiday and double holiday weeks when processing time is reduced and deadlines remain rigid. The procedure for delivering this data via magnetic tape will be maintained as a safety provision. Work continued on the electronic SANDI (Staff labor/distribution) System.

Work began on the automating of the legislatively imposed salary limit for retirement plan participation; the elimination of paper time sheets in favor of the electronic time report system; and the automating of the sponsored research vacation process which includes the maintenance of employee balances, the vacation cost accruals forecasting for employee benefit rate settings, and the generation of salary credits to the research project involved.

Financial Systems

A new Travel System was installed in November 1993 enabling the Travel Office to process transactions more efficiently, and a new Cashier System was installed in June 1994 greatly enhancing the Cashier's Office function and improving the Institute's cash management capabilities.

In addition to the changes in the supplemental overhead rate, it was determined that Undergraduate Research Opportunities Program (UROP) salaries and wages must bear overhead and employee benefit charges and this function has been added to the General Ledger System to be activated in Fiscal Year 1995. Many changes have been made to the Investment System to enhance and improve its operation, and one of the major enhancements provides accounting information on an on-demand basis. To meet requirements of the Financial Accounting Standards Board, several changes were made to the Chart of Accounts and several new reports were produced to provide the required information.

Benefit Accounting

New validation rules were implemented to insure integrity of member data being entered into the Pension Accounting System. Work continues in this area and will be an ongoing project as plan provisions change. The monthly accrual close process is being enhanced to generate accounting entries, previously computed manually, consistent with member status changes. Work was begun on a task to generate the retirement plan contributions for members defined as highly compensated who are on Long Term Disability to insure the proper classification of such monies according to plan provisions. A project was implemented which integrated the COBRA payments program with the Cashier's System to provide increased control, security, and time savings.

Investment Accounting

Procedures were implemented to allow for the electronic transfer of data from the Bank of Boston to MIT for the Investment Accounting System eliminating the need to manually input approximately 80 percent (of an estimated 45,000 annual entries) of investment data received from the Bank of Boston.

THE PROPERTY OFFICE

The Property Office is responsible for the accounting and asset management of more than 100,000 items of equipment which are both MIT-owned as well as sponsor-owned. During the year, 13,120 newly acquired items of moveable equipment were identified and tagged, representing a six percent increase over the previous year. The biennial inventory and reconciliation of items of moveable equipment was completed. Two hundred sixty-seven final inventories were submitted as part of closing out the contracts, grants, and agreements. There were 513 financial reports prepared and submitted to various government agencies. Forty-six items of excess government equipment with an original acquisition cost of $239,000 were acquired. Four hundred ninety-six items of equipment with an acquisition value of $373,000 were transferred between MIT departments as part of a reutilization program. Equipment, unneeded or unusable by the MIT Community, was sold for $201,637 providing funds for replacement equipment. Four hundred fifty-four items of equipment were donated to non-profit organizations.
Property management responsibilities at the Laboratory for Nuclear Science (LNS) and the Bates Linear Accelerator, previously performed by two recently retired LNS staff members, were assumed by the Property Office staff. A distributed computing environment for the Property Inventory and Accounting System replaced a centralized input, update, and reporting environment. Requests from various academic and administrative departments for equipment information resulted in over 700 reports being generated and distributed to the departments.

LINCOLN FISCAL OFFICE

A new enhanced Accounts Payable System was introduced in October 1993 and has improved efficiency in tracking of unpaid invoices, invoices pending approval, and problem situations. All this information is disseminated throughout the laboratory via the Automated Purchasing System providing the various groups and divisions with up-to-date information for all transactions on any particular purchase order.

In a cooperative effort among the Lincoln Fiscal Office, the Comptroller's Accounting Office, and Lincoln Laboratory, major steps have been accomplished in revamping the Lincoln Information System (LFOINFO). This new system will utilize the client server technology and is expected to greatly enhance the flow of management information and the abilities of the various laboratory departments to interpret that information. This system is targeted for introduction in early Fiscal Year 1995. Plans are underway to rewrite the LFO Cashiering System for implementation in Fiscal Year 1995.

Personnel Changes

The following staff changes occurred within the Comptroller's Office during the past year:

New Appointments

Joseph D. Keohan  
Property Auditor

Promotional Appointments

William H. Connelly, Jr.  
Staff Accountant
Leona A. Cresey  
Staff Accountant
Steven G. Dummer  
Analyst/Programmer I

Resignations

Elizabeth A. Lynds  
Analyst/Programmer III
Gail B. Tetrault  
Staff Accountant

Retirements

Stanley Miller  
Assistant to the Comptroller  
43 Years of Service
Elizabeth C. Nelligan  
Senior Accounting Officer  
39 Years of Service

Promotions

Donald R. Comeau  
Property Officer
Selwyn M. Eccles  
Senior Staff Accountant
William J. Fitzgerald  
Assistant Comptroller
Michael J. Glynn  
Senior Analyst/Programmer
Paul J. Honiker  
Manager of Administrative Services
William F. Huxley  
Manager of Data Processing
Kenneth F. LeVie, Jr.  
Senior Staff Accountant
Ellen M. Sico  
Assistant Accounting Officer
Frank J. Silva, Jr.  
Accounting Officer
Scott T. Thornhill  
Senior Accounting Officer
Carol E. VanAken  
Assistant Comptroller

PHILIP J. KEOHAN
FISCAL 1994 RESULTS OF OPERATIONS

Total operating expenses for the year were $1,137,474,000, an increase of 0.3 percent from the previous year. Total operating revenues increased 0.9 percent to $1,131,282,000 leaving a deficit in operations of $6,192,000 after the use of all unrestricted gifts not designated by the Executive Committee for other use. The deficit was funded by the use of $1.9 million of current income on reserves and $4.3 million of funds functioning as endowment. Offsetting the use of funds functioning as endowment was the additional distribution of $489,000 from the unrestricted bequest of William A. Coolidge which was added to the $8,400,000 received from this source in Fiscal 1993. Once or twice in a decade MIT receives large unrestricted bequests of this magnitude and it has been our policy, given the frequency of these gifts, to add them to funds functioning as endowment in honor of the donor. The budgeted deficit approved by the Executive Committee in May of 1993 was $10.3 million. This deficit was revised upward to $14.1 million in forecasts during subsequent months, and modified to $6.2 million at financial closing. The net change in the deficit of $4.2 million was comprised of adverse effects of $5.2 million and positive effects of $9.3 million.

The adverse effects which increased the deficit by $5.2 million were similar to those contributing to the financial pressures of the last few years. These included a decrease in indirect cost recovery revenues ($3.9 million) and lower unrestricted gifts than budgeted ($1.3 million).

The major positive impacts provided a $9.3 million offset to the adverse effects. These included significant unexpended budgets ($3.4 million), and a favorable tuition and other income over budget ($1.0 million), and a one time increase in unrestricted revenues ($3.2 million).

It is important to note that modest surpluses or deficits in operations do not convey the underlying financial strength of MIT. A better measure of this strength is found in the growth of the Institute's fund balances. These balances, net of borrowing, have increased by a total of $704 million over the last five years, or an average of $141 million per year. The book value of the Institute's fund balances was $2,060,271,000 as of June 30, 1994.

FINANCIAL PLANNING

MIT's financial plan was converted from a four year plan (Fiscal 1994 through 1997) to an eleven year plan (Fiscal 1994-2004). The new plan shows the long term impact of current goals and objectives. These objectives include maintaining excellence, need based financial aid for undergraduates, moderating the increase in tuition rates, fully supporting academic year faculty salaries from MIT resources, competitive salary structures, enhancing diversity, and maintaining flexibility to try new things.

The purpose of the new financial plan is to integrate all the goals and objectives and to highlight the need for adding or moderating these objectives. For example, the salary base net of sponsor support is about $195 million and the tuition revenues net of unrestricted student aid is about $174 million. Clearly a strategy of increasing salaries at a rate higher than inflation while limiting tuition increase to the rate of inflation creates a growing unfavorable gap between expenses and revenues. The longer time frame of the plan highlights the need to introduce other strategies to offset that growing imbalance.

In March 1994 MIT's reengineering effort began with the objective of streamlining and improving the quality of the Institute's administrative processes, and in reducing costs. The current financial plan anticipates the success of this effort and the conversion from a deficit position to one of surpluses in three years depends on it.

CAPITAL BUDGET

At the end of the year the Institute's capital and major renovations budget was $398 million for 13 active projects. These figures include land acquisition, construction, financing, and, where appropriate, funds to cover the unrestricted portion of building operating costs for ten years. Direct construction costs are $234 million with interest expense of $154 million on financings extending from ten to thirty years, depending on the project. The remaining costs include $6.2 million for acquisition and $3.4 million for operating expenses. The net present value of these projects, discounted at 6%, is $260 million.
The book value of the educational plant assets was $431,083,000 at June 30, 1994 up from $383,968,000 at June 30, 1993. This change includes $82,015,000 of additions to educational plant offset by $34,900 of depreciation charges.

Major projects completed during the year include the construction of the new Biology Building at 31 Ames Street, the construction of the Northeast Utility Corridor from the Biology Building to the Central Utility Plant on Vassar Street, and the construction of a 55-bed shelter at 240 Albany Street for the Cambridge and Somerville Program for Alcoholic and Drug Rehabilitation (CASPAR). The renovation of 40 Massachusetts Avenue to accommodate the MIT religious counselors, the Kosher Kitchen, and other student religious activities, was substantially completed. The construction of the Cogeneration Plant on Vassar Street, including the upgrade of the electrical distribution and control systems in the existing plant, continued during the year. The excavation and construction work for the foundation of the addition to 70 Memorial Drive, which will be called the Jack C. Tang Center for Management Education and used by the Sloan School of Management, is ongoing. The renovation of 311-312 Memorial Drive as an annex to McCormick Hall, the Institute's all-female dormitory, to house approximately 25 women is ongoing and is expected to be completed in the Fall of 1994. The renovation and upgrade of three undergraduate teaching laboratories and the student projects workshop for the Department of Mechanical Engineering, to be renamed The Pappalardo Engineering Projects Laboratory, started during the year and is expected to be completed by the end of 1994. The planning and design for the renovation and upgrade of the Dorrance and Uncas A. Whitaker Buildings are underway.

Total indebtedness for educational plant at June 30, 1994 was $163,323,000 of which $133,490,000 is tax-exempt debt financed through the Massachusetts Health and Educational Facilities Authority.

FINANCIAL SYSTEMS

During 1993-1994 we concentrated on improvements to replace manual systems. We implemented the on-line chart of accounts interface between the OFPM database and the Institute's chart of accounts. General account information is now created and maintained via an on-line OFPM module that directly updates the Institute's chart of accounts. During the past year, we also completed programming for fund draft processing. The journal vouchers for fund drafts are now created and transmitted electronically to CAO for inclusion in general ledger processing. Since we use budget transactions to create the general ledger entries, we can now link both the budgeted and actual fund support to a specific activity. Thus, we have the ability to develop fund draft reports (comparing budget and actual details) from the system. Final testing of voucher processing and generation of standard reports was completed during the fiscal year closing. The automation of this process has eliminated the need for data reentry in both OFPM and CAO, it has reduced the number of errors, and it has reduced the time needed to process and monitor fund draft transactions. In addition, during the FY95 budget submission, we continued to refine our ability to accept electronic budget data from a variety of department budget development platforms. The improvement in data collection techniques allows us to spend more time analyzing the data submitted and identifying and resolving problems in a more timely manner.

PERSONNEL AND ORGANIZATION

Wayne Turner was one of two MIT employees honored as a YMCA Black Achiever and in late spring he was honored again by being inducted into Northeastern University's Sports Hall of Fame. Ugebai M. Poweigha left at the end of the year to pursue other interests. We will miss her cheerful spirit.
Office of Purchasing and Stores

Major projects completed, continued, or initiated this year include:

(1) **Consolidation of On Campus Purchasing and Subcontracting Functions**

A proposal to consolidate on campus purchasing and subcontracting functions, which was submitted in response to the call for budget reduction initiatives, was approved by the Provost and Senior Vice President, with an effective date of July 1, 1994.

The consolidation will eliminate the separate purchasing agencies at the large research laboratories and centers and will centralize all purchasing and subcontracting at the General Purchasing Office and the Central Subcontracting Office. A limited number of personnel from the separate purchasing agencies will be transferred to augment the staffs of the central offices. The consolidation will reduce the number of personnel required to perform the purchasing and subcontracting functions by nine. Seven positions will be eliminated as of July 1, 1994, with two additional positions scheduled to be eliminated during FY95 or 96.

(2) **EREQ System**

EREQ is the Institute's on-line and interactive electronic requisitioning system. EREQ was approved and funded by the Administrative Computing Steering Committee and developed by the Office of Purchasing and Stores. This free service is available to all members of the MIT community.

EREQ supports the following major functions:

- **Electronic Requisitioning to Purchasing.** Users are able to create and instantly forward requisitions to the General Purchasing Office or to a participating research laboratory purchasing office for review, processing, and purchase order issuance.

- **Electronic Speed Orders.** If the value of an electronic requisition is $500 or less, the user is able to specify the immediate assignment, on-line, of a purchase order number which he/she can promptly relay to the vendor. (Commencing July 1, 1994, the dollar limit for an electronic speed order will increase to $1,000.)

- **Electronic Requisitioning to Office of Laboratory Supplies.** Users are able to create and instantly forward requisitions to the Office of Laboratory Supplies for order filling and delivery, usually the next day.

- **Electronic Requisitioning to Internal Providers.** Users are able to create and instantly forward requisitions to MIT departments, laboratories, and centers that are suppliers of goods and/or services for internal use.

- **Electronic Routing.** Electronic routing dramatically speeds the processing of requisitions as it enables routing requisitions electronically for on-line reviews and approvals (i) to account supervisors, account addressees, and central fiscal offices, as required and as may be stipulated for each account number; (ii) to other administrative offices as required by MIT policies and procedures and federal contract and grant regulations; and (iii) to the Office of Laboratory Supplies or to any Internal Provider for requisition fulfillment.

- **Access to Purchasing and Accounts Payable Systems' Information.** Users are able to get up-to-the-moment information on the status of requisitions, purchase orders, and invoices within the Purchasing and Accounts Payable databases.

Use of the EREQ system increased by 27 percent this year. Over 1,700 users logged-on to the system 95,000 times, generating 216,500 transactions to (i) view the status of their business, (ii) create 31,500 electronic requisitions and speed orders to outside vendors, and (iii) create 10,600 electronic requisitions to the Office of Laboratory Supplies and other Institute Internal Providers. A similar increase is expected next year with the use of the EREQ system by the large research laboratories and centers in connection with the consolidation of purchasing and subcontracting functions.
EREQ system Internal Providers now include the following MIT organizations:

- Audio Visual Service
- MIT Catering
- MIT Computer Connection
- Computer Services/PC Service
- Cryogenic Engineering Lab
- Graphic Arts
- Network Services
- Physical Plant
- Quick Copy Centers
- Supercomputer Facility
- Telecommunications

During the coming year, we expect additional MIT organizations to become EREQ system Internal Providers.

(3) **VAPS System Replacement**

VAPS is the acronym for "VAX Computer for Accounts Payable and Purchasing." The Purchasing, Stores, and Accounts Payable automated systems run on this computer as does the EREQ system.

The Administrative Computing Steering Committee approved our proposal to purchase a Digital Equipment Corporation VAX 7000-610 computer to replace our VAX 8550 computer which was seven years old and had reached the end of its useful life.

(4) **Vendor Trade Show**

On September 30, the Office of Laboratory Supplies hosted its annual large-scale vendor trade show on campus grounds.

Over one hundred of the Institute's most often used vendors displayed their product lines in booths beneath a large tent in McDermott Court. Several thousand MIT employees and students visited the show to view and discuss new products with vendor representatives and to collect catalogs and sample products which vendors provided. All costs associated with the show were offset by a "booth fee" which each vendor paid.

(5) **Cambridge First Day**

"Cambridge First Day" is the theme developed to remind and inform City of Cambridge officials, business owners, and residents of the substantial purchasing business which MIT places each year with Cambridge companies.

MIT's purchasing offices employ a "Cambridge First" policy in their purchasing activities, with the goal of placing as much business as possible with Cambridge companies. This resulted in over $27 million of purchasing business placed this year with nearly 800 Cambridge companies.

By resolution, President Vest proclaimed June 20 as "Cambridge First Day" at MIT. As part of "Cambridge First Day" festivities this year, the Institute sponsored a "Community Partners Reception" in honor of Cambridge minority and woman-owned businesses that work closely with MIT as suppliers of goods and services. Certificates of Appreciation were awarded to representatives of 25 minority and women-owned businesses at a lunch reception that was attended by the Mayor of Cambridge and MIT officials and members of the purchasing offices.

**General Purchasing Office**

Purchasing activity continued at a high level. Of a total 69,100 purchase orders issued by all on campus purchasing agencies (93,800 purchase orders issued, less 24,700 of which were electronic speed orders issued by EREQ users), the General Purchasing Office processed and issued 37,400 or 54 percent of the total.

Since the primary responsibility of the office is the purchase of required goods and services at lowest practicable prices, major emphasis continued to be placed on negotiating discount agreements and other favorable pricing arrangements with suppliers.
Office of Laboratory Supplies

The office processed and filled 76,000 requisitions containing 252,000 line items of commonly used supplies, tools, devices, and furniture and furnishings.

Combined sales of office and laboratory items and furniture and furnishings decreased 3.2 percent compared to the previous year. Sales of office and laboratory supplies remained level while sales of furniture and furnishings decreased 8.8 percent.

Minority and Women-Owned Business Purchasing Programs

Business placed Institute-wide under these affirmative action procurement programs resulted in the award of over $18.5 million to minority and women-owned business concerns. This represents an increase of 10.1 percent over last year's accomplishments. Over $7.5 million was awarded to 466 minority businesses and over $11.0 million was awarded to 997 women-owned businesses.

Subcontracting Plans Under Federal Contracts

Subcontracting Plans are required (by law) for each contract proposal to a federal agency which exceeds $500,000. The Subcontracting Plan specifically identifies the efforts that will be taken under a resulting contract to assure the award of a fair proportion of subcontract and purchasing dollars to small business concerns and small minority business concerns. The Subcontracting Plan includes both dollar and percentage goals which are negotiated with the sponsor and become a material part of the resulting contract.

As a service to departments, laboratories, and centers, the Assistant Director for Subcontracting coordinates with the Office of Sponsored Programs and principal investigators, prepares Subcontracting Plans for submission, negotiates changes when necessary, and reports accomplishments to federal sponsors and principal investigators. This year there were 50 active Subcontracting Plans under Institute federal contracts which necessitated the submission of over 100 separate reports of accomplishments to federal sponsors. Additionally, in order to provide guidance and assistance to principal investigators, over 100 internal progress reports were issued.

There have been indications that Subcontracting Plan requirements may be extended to federal grants also. In this event, the workload in this area will more than double.

BARRY ROWE
Several significant events can be recorded for the past year.

In the Bursar's Office, continuing efforts to enhance its service to students through redesign of the student accounting system are meeting with success. For example, the Bursar will discontinue the payroll deduction plan which was highly labor intensive and was used by only a small number of students. It will be replaced by an automatic direct debit payment plan which will take full advantage of improved banking technology and will be available and of benefit to many more students.

Service to students will also improve when a new billing format is introduced next fall. It has been completely redesigned from the customer service standpoint, as a result of a survey of students and their parents about what they liked and did not like in the current bill, and how they would like to see it improved.

Both these changes will become permanent features of the new Student Information System (SIS).

In the Registrar's Office major efforts continue in the development of the new Student Information System (SIS) authorized by the Administrative Computing Steering Committee four years ago. This project was undertaken so that we could replace the existing batch SIS (now over 20 years old) with an on-line, full-featured system in a relational database environment. The four phases of this project, System Construction, Acceptance Testing, Training and Conversion, have been pursued in parallel this year, and are nearly complete. Some unforeseen difficulties have necessitated a change in our development schedule, however, and we now plan to have significant portions of the new system on line in late October, 1994.

In the Student Financial Aid Office the proposal was made and accepted by the Administration that MIT apply for inclusion in the next group of colleges or universities to be accepted by the Department of Education into the federal Direct Loan Program. This program was an initiative of the Clinton administration that evoked major controversy in the Higher Education community when it was introduced last year. It will eliminate private lenders and guarantee agencies from the Student Loan program, the first major change in the delivery of federal student aid in 20 years.

The suit has been settled in which the Justice Department charged that MIT's agreement with other schools (notably the Ivy League) to award our own grant and scholarship dollars on the basis of students' financial need rather than on a competitive merit-oriented basis was in violation of the Sherman Anti-Trust Act. In the light of the findings, on appeal, by the Federal Third Circuit Appeals Court in September, the Justice Department agreed to dismiss the case, and as a result MIT and other schools may now renew their cooperation in the administration of need-based aid for undergraduates.

In the appeal preceding the settlement, all three appellate judges said the earlier ruling against MIT by the U. S. District Court in Philadelphia should be reversed. One judge, Joseph F. Weis, Jr., ruled unequivocally in favor of MIT, saying that the 1890 Sherman Antitrust Act did not apply in this case. Judge Weis said, "It does seem ironic . . . that the Sherman Act, intended to prevent plundering by the 'robber barons,' is being advanced as a means to punish . . . philanthropy."

These events and accomplishments are discussed in further detail, and others reported, in the individual reports that follow from the Bursar, Registrar and the Director of Student Financial Aid.

JACK H. FRAILEY, DIRECTOR
BURSAR'S OFFICE

This was a quiet year with few changes. We hosted the “Little 12” Bursar’s Conference in October, which was well attended by our colleagues from other universities. The major topic was the Myers-Briggs Type Indicator test as a basis for discussion of effective management styles.

Alumni Services

We discontinued new collection efforts with the legal firm McKenzie and Edwards, P.C. and conducted an orderly transition of the accounts previously placed with them. We negotiated an agreement with a new collection agency—CTI, Inc.

Working with the Benefits Office, we revised the application and procedures for the Educational Loan Plan for employees. The requirement for a cosigner on the promissory note was eliminated and the annual and total borrowing limits were increased.

Student loans receivable totaled $53,450,245 at fiscal year end. These notes were funded by $14,560,148 of MIT loan funds established by friends and alumni of the Institute; $25,607,941 of federal funds in support of the Perkins Loan Program; $10,182,157 borrowed from the Student Loan Marketing Association; and $3,100,000 borrowed from local banks.

Default Rates

MIT’s cohort default rate on Perkins/National Direct Student Loans was 1.4 percent in 1993 and 1.1 percent in 1994. MIT’s default rate on Stafford/ Guaranteed Student Loans was 2.5 percent in 1993. We are very proud of our performance over time in this area, as shown in the attached two graphs. Here is some additional information on student loan default rates.

The Federal Perkins Loan program was formerly known to borrowers as the National Direct Student Loan Program, and before that as the National Defense Student Loan Program. These loan funds are provided to MIT by the federal government. The repayment period depends on how much is borrowed, and may be as long as ten years. The interest is fixed at 5% per annum. MIT awarded $3,048,035 of Perkins loans in 1993-94. The total MIT Perkins loan portfolio (“notes receivable”) as of June 30, 1994 was $28,118,792.

The Federal Stafford Student Loan program was formerly known to borrowers as the Guaranteed Student Loan program and before that as the Federally Insured Student Loan program. These loans are issued by banks and other lenders, including MIT, which is a small lender to graduate students. The repayment period also depends on how much is borrowed, and may be as long as ten years. The interest rate is variable and is revised each year. The interest rate for 1993-94 is 6.2% per annum. MIT awarded $235,175 of Stafford loans (as a lender) in 1993-94. MIT students borrowed an additional $14,909,125 of Stafford loans from banks. The total MIT Stafford loan portfolio (“notes receivable”) as of June 30, 1994 was $3,324,871.

Formulas for calculating default rates of these programs are specified by the federal government, and have changed over the time period of the graphs. However, in any given year on the graphs, the MIT and national data have been calculated with the same formula so they can be compared.

Historically, “default rate” has been a fraction expressed as a percentage: the numerator was dollars a certain number of days or more past due; the denominator was dollars in matured (i.e., not enrolled or grace) loans plus loans paid in full. Recently, formulas have been established for “cohort default rate”, which is also a fraction expressed as a percentage: the numerator is number of borrowers a certain number of days or more past due; the denominator is number of borrowers who entered repayment in cohort year. The number of days used in the numerators has been 120, 180, and 240.

Financial Systems

Our programmers spent most of the year analyzing, designing, programming, testing, and documenting various processes for the Student Information System.

We designed and implemented a new automated process for reconciling loan accounts and for recording loan fund monthly transactions.

We worked with the Comptroller's Accounting Office to simplify the cash receipts process.

We made several changes to computer programs as required by new federal regulations (new deferment privileges, etc.).

Student Services

For the second time in as many years, there were no financial holds of students who graduated in June 1994.

Changes in regulations and technological advancements contributed to shifts in some of our work. PLUS Loan check activity increased to five times the level it was the previous year. Stafford Loans continued to increase our use of electronic funds transfer (EFT) as a replacement for checks.

Statistics on wire transfers of student account payments indicate a 47% increase in that activity over the previous year. The increased use of this technology encourages our planned introduction of an Automatic Direct Debit payment plan next year.

The number of returned checks continues to decline. Seldom does a returned check remain an outstanding receivable for long.

Student tuition, fees and other charges totaling $213,261,642 were billed, an increase of 5.2% from last year. Servicing the 23,750 student accounts required 209,568 transactions to the student accounts receivable system. The amount collected as a percentage of the total receivable was 97.5 percent. Income from late payment fees was $122,303; income from finance charges was $137,193.

There were 206 active Parent Loan Plan accounts, of which 35 were new borrowers this year. A total of $1,765,485 was disbursed during the year and $1,545,626 in principal was collected. The PLP receivable at the end of the fiscal year was $1,729,530.

The total student population supported by a sponsor (government, military, etc.) for the academic year 1993-1994 was 613, representing total billing to sponsors by the Bursar's Office of $10,186,808.

Staff Notes

Cheryl Blankenship gave a presentation entitled "Regulations That Affect Student Accounts" at the annual American Student Assistance conference. Carolyn Bunker and Sandra Chauncey served as readers of undergraduate applications for the Admissions Office. Shirley Picardi served on the SHARE Loan Advisory Board of the Consortium for Financing Higher Education; the long range strategy committee of the Association of Alumni and Alumnae of MIT; and the reengineering project "Core Team" working with the CSC Index consultants. Shirley Picardi and Ann Reilly served as academic advisors to freshmen.

The following changes in staff occurred:

Valerie Bryce left her temporary position as Assistant to the Bursar/Student Services in November to relocate to New York.

Ellen Connare left her temporary position as Assistant to the Bursar/Financial Systems in August to relocate to New Hampshire.
Barbara Doyle was promoted in March from Analyst/Programmer III to Assistant Bursar/Information Systems.

Ann Reilly was promoted in March from Analyst/Programmer II to Analyst/Programmer III.

SHIRLEY PICARDI, BURSAR

REGISTRAR'S OFFICE

Registration

In 1993-94 student enrollment was 9,790 (compared with 9,798 in 1992-93). There were 4,509 undergraduates (4,520 the previous year) and 5,281 graduate students (5,278 the previous year). The international student population was 2,196, representing eight percent of the undergraduate and 35 percent of the graduate populations. These students were citizens of 101 countries. (Students with permanent residence status are included with US citizens.)

In 1993-94, there were 2,757 women students (1,528 undergraduate and 1,229 graduate) at the Institute, compared with 2,722 (1,506 undergraduate and 1,216 graduate) in 1992-93. In September 1993, 369 first-year women entered MIT, representing 34 percent of the freshman class of 1,081 students.

In 1993-94, there were, as self-reported by students, 2,417 minority students (1,905 undergraduate and 512 graduate) at the Institute, compared with 2,271 (1,806 undergraduate and 465 graduate) in 1992-93. Minority students included 346 African Americans (non-Hispanic), 41 Native Americans, 478 Hispanic Americans, and 1,552 Asian Americans. The first-year class entering in September 1993 included 502 minority students, representing 46 percent of the class.

Degrees Awarded

Degrees awarded by the Institute in 1993-94 included 1,092 bachelor's degrees, 1,230 master's degrees, 31 engineer's degrees, and 516 doctoral degrees -- a total of 2,869 (compared with 2,812 in 1992-93).

Tabular Presentation

Most of the above 1993-94 figures are taken from the several tables that follow this report. These tables, together with others dealing primarily with historical comparison and demographic data, comprise the annual Registrar's Report, separately published and available upon request.

Major Accomplishments for the Year

The following highlights some accomplishments in addition to the normal services provided by the Office in the areas of registration; student address/biographical information; certification of MIT attendance; transcripts; maintenance of academic records; tuition administration; cross-registration; subject, classroom, and exam scheduling; classroom maintenance, renovations, and furnishings; Academic Calendar; degree applications and audit; Commencement and diploma preparations; Catalogue subject/curricular management; interpretation of policy; operations and maintenance of Student Information System; privacy of information; and statistical reporting:

- Strengthen support of the Institute's academic programs: assisting the work of various Faculty Committees (e.g., supporting the Schools in implementing the new Minors in Science and Engineering; reviewing MIT grading policy; reviewing policy issues and proposals related to the new
Physics curriculum and IAP-only subjects; refining the Master of Engineering degree program in Course 13 within CGSP guidelines; developing alternative registration protocols for interdepartmental graduate programs; implementing the new Institute Calendar for the coming academic year, including special provisions to accommodate the conflict between Rosh Hashanah and Registration Day; supporting implementation of the new HASS-D lottery system.

Collaborating extensively with Physical Plant, Undergraduate Education and Student Affairs (UESA), and Planning Office regarding use, maintenance, and renovation of classrooms; assisting the UESA in enlisting faculty support on classroom maintenance issues; assisting in a variety of classroom renovations and upgrades, including the new Tang Center addition and new lecture hall blackboards that will pay for themselves in three years through avoided maintenance costs; supporting the department in developing a new scheduling scheme for Freshman Physics (8.01), which will be taught in a totally different format and style next Fall; collaborating with Academic Computing and MIT Audiovisual to install advanced technical capabilities in specific classrooms; strengthening user support for the technically advanced classrooms to allow more effective use of the facilities; updating classroom renovation priorities and responding to special requests from departments/faculty; providing logistical support for the World Economic Forum's Industry Summit.

Fulfilling a wide variety of requests for information, statistics, and analysis by the Senior Administration, Schools, Committees, etc.; undertaking a 25-year analysis of crossregistrations between MIT and the various Schools at Harvard, including ROTC cross-registration; providing substantial support in the planning and design of the Senior Survey, including procedures to guarantee student privacy; redefining the concept of "semester hour", particularly for law and medical school applicants; assisting the International Student Office in defining categories of visiting students doing research at MIT; assisting with the development of back-up plans for Commencement and providing more extensive support for the academic deans; assisting the Corporation in modifying its by-laws to more appropriately define eligibility to nominate and/or vote for representatives of recent classes.

Continue the major effort to develop a new Student Information System (SIS): Substantial effort within the Office was focused during the past year on reaching the goal of developing and implementing by October 31, 1994, a new on-line Student Information System serving all of the student-related areas at MIT. Major accomplishments in the development process include: completing the detailed specifications of the new system from the users' perspective; making substantial progress in the coding and testing of much of the system; making substantial progress on the conversion from the old IBM system to the new system; making disaster recovery provisions on the new SIS; assisting other offices with the development of their computer systems; making enhancements in the Catalogue and Commencement PC systems to accommodate conversion to the new SIS and upgrading Office hardware to get set for the new SIS; keeping the old student system running while developing the new SIS.

Helping the Reengineering Steering Committee understand the substantial reengineering that has been undertaken as part of development of the new SIS, and the significant benefits to deferring reengineering in the Student Services area until six to nine months after the new SIS has become operational -- so that the community can become familiar with its capabilities and functionality to provide a basis for defining a clear vision of the future.

A few of the significant improvements include: on-line real-time interactive access to current and archival records; rule-based, table-driven architecture for user ease and minimal maintenance; extensive audit trails of financial and academic transactions; significant expansion of the student information that can be viewed and/or updated by academic departments/faculty; significant reduction in paper and increased flexibility to respond to departmental requirements; complete integration and reconceptualization of the pre-registration, scheduling, and registration procedures for greater ease, efficiency, and timeliness; greater depth and clarity of the information on students' academic records; capability for students to preregister and update information on Athen...
their academic record and other public and private information; electronically prepared academic transcripts and certifications of attendance (enhanced speed and quality); elimination of the pre-registration process for graduate students attending Summer Term; MIT-assigned ID numbers (for privacy, consistency); automation of "future term" record maintenance; reconceptualization and integration of descriptors of student's enrollment status; flexible student address structure allowing multiple, time-ranged addresses; grading, degree audit, entrance status, tuition, and future term eligibility structures that are rule-based and flexible.

- Strengthen effectiveness in administrative procedures and office operations: working with the Communications Office to improve the design and effectiveness of the MIT Catalogue; supporting UESA in the creation of guidelines for event registration; expanding services and hours of operation in the satellite Registrar's Office in the main building, including collaborative arrangements with the Medical Department (Medstop) and the Dean's Office Public Service Center.

Holding a series of planning seminars/discussions for staff and support staff on the proposed functionality of the new Student Information System; initiating a process to fully document future operations in the Registrar's Office as part of developing an operations manual for the new SIS; expanding communication and cooperative efforts with other offices to smooth procedures (International Student, Admissions, UAA, Harvard cross-registration, HASS, etc.); defining procedures for groups wishing to distribute information at the Registration Day location; coordinating development of policies and procedures with the Housing Office for implementation of the new "MIT Card".

**Important Issues on the Agenda**

a) Complete development of the new Student Information System, and make optimal use of the SIS in providing effective services to students, faculty, and the administration. b) Strengthen the academic research capabilities and involvements by the Registrar's Office. c) Continue the collaborative effort to develop an extensive renovation and maintenance program to provide first-rate classroom/lecture facilities at MIT.

**Staff Notes**

Daniel Engelhardt was inducted into the Quarter Century Club this year, joining Josephine Eisner, Elizabeth Bradley, and Roberta Welch. Mary Callahan and Constance Scribner were promoted to the positions of associate registrar, Stephen Turner to senior analyst programmer, and Lisa Rung to assistant to the registrar. Bonny Kellermann left the Office to become recording secretary in the Deputy Treasurer's Office.

Staff members were involved in numerous ways in Institute faculty committees, Institute community service, community outreach, freshman seminar program, freshman advising, admissions folder reading, etc. We appreciate the many accomplishments and contributions of all the members of the Registrar's Office in service to the Institute.

DAVID S. WILEY, Registrar

**STUDENT FINANCIAL AID OFFICE**

The year brought a consolidation of the new financial aid application processing mandated by the federal government. Procedures that completely separated the federal application process from institutional processes were in their second year. As a result, all the participants - students, parents, secondary schools, and MIT had experience with the new processes. The disruption in the delivery
system experienced in the previous years were eliminated, and application processing was completed on schedule for first-time and continuing students.

During the year, the Clinton administration brought forward two new financial aid initiatives: Community Service and Direct Loans. While the Community Service program continues to be a very limited program having little impact on the programs at MIT, the Institute has elected to participate in the Direct Loan program that will eliminate private lenders and guarantee agencies from the student loan program. This is the first significant change in the delivery system of the student aid programs in 20 years. The Institute has begun the implementation of this program and will make its first loans in this new format in FY 95.

The reviving economy during the 1993-94 academic year began to help take the pressure off the need-based assistance for undergraduate students. The average need for undergraduates increased by 6% to $18,761 while the total number of needy students increased slightly to 2,660. Overall, scholarship expenditures increased by 3.1%. The incidence of unemployment declined, and as parents' financial circumstances improved, the demand for institutional funds decreased. In addition, support from outside grant sources increased. Outside grants from private sources and the Federal Pell program increased. In addition, new rules governing the Federal Campus-based programs allowed transfers of Work Study and Perkins Loan funds into the Federal Supplemental Educational Opportunities Grant fund. Scholarship funds from MIT's endowed and current funds increased 7% helping to reduce the need for unrestricted funds to augment the financial aid program. While the use of unrestricted funds for scholarships was still significant, representing 47% of all grant assistance provided, this proportion was down from the previous year and significantly below the 52% of all grant aid budgeted for FY94.

Scholarships and Grants*  
(Awarded to Undergraduates with Need)  
($)000's

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* All of the numbers reported in this section reflect awards from the academic year perspective and will not agree exactly with fiscal year records reported by the Bursar, Comptroller or Treasurer.

¶ Including MIT Opportunity Awards and Special Program Grants.
Loans

The reauthorization of the federal aid programs brought significant increases in eligibilities for federal loans to undergraduate and graduate students. Use of the Perkins Loan fund for undergraduates decreased as eligibility for Stafford Loans was broadened by the Federal government. Overall, loans to undergraduates increased by 15% while loans taken by undergraduates through the Stafford Loan Program increased by 34%. Loans to graduate students overall increased by 5% while loans taken through the Stafford Loan Program increased by 10%. The unsubsidized Stafford Loans for students without need increased dramatically for undergraduates in 1993-94 as students and parents learned of the availability of these loans.

Loans *
(Received by Needy and Non-Needy Students)
($000's)

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* All of the numbers reported in this section reflect awards from the academic year perspective and will not agree exactly with fiscal year records reported by the Bursar, Comptroller or Treasurer.

Work Programs

The College Work-Study Program allocation remained at the 1993 level, and was used exclusively to subsidize the on-campus student employment program for both undergraduate and graduate students. About one third of the grant subsidized undergraduate employment and about two thirds supported graduate assistantships.
Other Activities

The development of the new student information system, scheduled to come up in FY95, was a continuing effort during the year. Plans to reengineer the processes that bring financial aid services to students and parents have been developed as part of the system implementation.

On December 22, 1993 the U.S. Justice Department agreed to dismiss the financial aid antitrust case against MIT. The settlement of the suit allows MIT and other schools to cooperate in the administration of need-based aid for undergraduates. The settlement recognized the obvious benefits to society produced by arrangements that are designed to make opportunities for higher education accessible to the most talented students without regard to their financial circumstances.

Staff Notes

Robert Weinerman joined the staff as Assistant to the Director in July. Katherine Nolan left her position as Associate Director in December.

STANLEY G. H U D S O N, DIRECTOR
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**WHITAKER COLLEGE of Health Sciences and Technology**

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*All figures include special students (special students also shown separately in parentheses).

*Non-resident graduate students*
### TABLE II  NUMBER OF DEGREES AWARDED IN SEPTEMBER 1993, FEBRUARY 1994, AND MAY 1994

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**SCHOOL OF ARCHITECTURE**

- Architecture: 16
- Undesignated: 1
- Architecture Studies: 8
- Art and Design: 5
- Building Technology: 2
- Media Arts and Sciences: 6
- Planning: 2
- Real Estate Development: 2
- Urban Studies and Planning: 2

**SCHOOL OF ENGINEERING**

- Aeronautics and Astronautics: 14
- Chemical Engineering: 6
- Chemical Engineering Practice: 5
- Civil Engineering: 8
- Civil and Environmental Engineering: 4
- Undesignated: 10
- Computer Science and Engineering: 10
- Electrical Engineering: 6
- Electrical Engineering and Computer Science: 3
- Electronic Materials: 1
- Environmental Engineering Science: 1
- Materials Engineering: 2
- Materials Science: 2
- Materials Science and Engineering: 1
- Undesignated: 6
- Mechanical Engineering: 11
- Metallurgy: 1
- Naval Architecture and Marine Engineering: 2
- Naval Engineer: 2
- Nuclear Engineering: 2
- Ocean Engineering: 2
- Ocean Systems Management: 3
- Polymers: 2

**Total**: 161

**SCHOOL OF HUMANITIES AND SOCIAL SCIENCE**

- Anthropology/Archaeology: 1
- Economics: 3
- History: 4
- Humanities: 1
- Humanities and Engineering: 1

**Total**: 1

---

5.4 Vice President for Financial Operations
| Humanities and Science | 1 | 8 |
| Linguistics            |   |   |
| Music                  | 6 |   |
| Philosophy             | 2 | 2 |
| Political Science      | 4 | 4 |
| Science, Technology    | 1 | 1 |
| Management Science     | 3 | 3 |
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| Office of Registration and Student Financial Services 515 |
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<td>Program in Science, Technology, and Society, STS</td>
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<td><strong>18</strong></td>
<td><strong>14</strong></td>
<td><strong>35</strong></td>
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<td><strong>179 (1)</strong></td>
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**SLOAN SCHOOL OF MANAGEMENT**

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<td><strong>11</strong></td>
<td><strong>20</strong></td>
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<td><strong>185 (4)</strong></td>
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**SCHOOL OF SCIENCE**

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<td>43 78</td>
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<td>54</td>
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<td>13 29</td>
<td>1 68</td>
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<td>Physics, VIII-A</td>
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<td>2</td>
<td>VIII-A</td>
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<td><strong>Total</strong></td>
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<td><strong>108</strong></td>
<td><strong>108</strong></td>
<td><strong>305 (5)</strong></td>
<td><strong>643 (5)</strong></td>
<td><strong>Total</strong></td>
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**WHITTAKER COLLEGE of Health Sciences and Technology**

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<td>- 13</td>
<td>TOX</td>
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<td>Undesignated</td>
<td>20 7 (7)</td>
<td>- 13</td>
<td>- 27 (7)</td>
<td>Undesignated</td>
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<td>First Year</td>
<td>369</td>
<td>383 (7)</td>
<td>376</td>
<td>1,185 (52)</td>
<td>369</td>
<td>First Year</td>
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</table>

| Grand Total                                 | 369     | 400 383 736 | 1,185 (52) | 44 | 2,757 (59) | Grand Total |

*All figures include special students (special students also shown separately in parentheses); not included are: 2 students in the third year.
3 students in the fourth year on Foreign Study; 1 student in the third year on Domestic Study.
2 Non-Resident graduate students.
TOTAL UNDERGRADUATE WOMEN: 1,528
518 Vice President for Financial Operations
for Financial Operations
Vice President
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For fiscal year 1994, the total volume of sponsored research performed on campus approximated $359,674,254. This represents a decrease of 0.5 percent over fiscal 1993 volume of $361,354,218 which was, in contrast, an increase of 12.1 percent over fiscal 1992. The breakdown by sponsor is shown in the table below.

Federally funded research volume increased by 0.9 percent over 1993 (which represented an increase of 12.5 percent over 1992). Department of Health and Human Services funding was down by 7.2 percent and the Department of Defense by 7.7 percent. Department of Energy funding increased by 10.2 percent, the National Science Foundation by 4.1 percent and the National Aeronautics and Space Administration by 15.9 percent.

Of the non-Federal sponsors, industrial funding decreased by 4.8 percent, compared with an increase of 15.8 percent in 1993 and an increase of 10.8 percent in 1992. Support from private foundations and other non-profit sponsors decreased by 7.5 percent. It should be noted that sponsorship characterized as non-Federal may, nonetheless, involve Federal funds when MIT receives a subaward from an industrial or non-profit sponsor which has a grant or contract from the Federal government.

### CAMPUS RESEARCH VOLUME BY SPONSOR - 1988-1994
(in thousands of dollars)

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<td>52,565</td>
<td>57,915</td>
<td>59,025</td>
<td>60,177</td>
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<td>DOE</td>
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<td>54,045</td>
<td>61,098</td>
<td>60,625</td>
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<td>DOD</td>
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<td>NSF</td>
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<td>38,962</td>
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<td>37,953</td>
<td>36,574</td>
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<td>NASA</td>
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<td>18,469</td>
<td>22,755</td>
<td>25,889</td>
<td>32,324</td>
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<td>Other</td>
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<td>6,713</td>
<td>7,430</td>
<td>8,647</td>
<td>9,773</td>
<td>8,899</td>
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<td><strong>Subtotal</strong></td>
<td><strong>$210,504</strong></td>
<td><strong>215,462</strong></td>
<td><strong>234,163</strong></td>
<td><strong>238,109</strong></td>
<td><strong>238,307</strong></td>
<td><strong>268,206</strong></td>
<td><strong>270,718</strong></td>
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<td>Industry</td>
<td>$35,315</td>
<td>41,937</td>
<td>46,223</td>
<td>48,360</td>
<td>53,578</td>
<td>62,068</td>
<td>59,117</td>
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<td>Nonprofit</td>
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<td>23,751</td>
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<tr>
<td>Other</td>
<td>$3,796</td>
<td>4,727</td>
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<td>5,599</td>
<td>5,461</td>
<td>5,487</td>
<td>6,173</td>
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<td><strong>Subtotal</strong></td>
<td><strong>58,890</strong></td>
<td><strong>70,266</strong></td>
<td><strong>76,496</strong></td>
<td><strong>77,710</strong></td>
<td><strong>83,959</strong></td>
<td><strong>93,148</strong></td>
<td><strong>88,956</strong></td>
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| **TOTAL** | **$269,394** | **285,728** | **310,660** | **315,819** | **322,267** | **361,354** | **359,674** |

### SIGNIFICANT DEVELOPMENTS

As in past years, a variety of continuing Federal developments and new events had an impact on sponsored research programs. Among these were the following:

**Indirect Cost Recovery**

Significant revisions to OMB Circular A-21, the Federal cost principles applicable to universities, were issued at the start of the year. As a result, the criteria for determining the allowability of indirect costs have been significantly narrowed and the retroactive application of those criteria has resulted in a reduction in allowable indirect cost recovery in a number of cost pools. In order to repay sponsors for over-recovery of costs during prior years, the otherwise anticipated actual rates for both 1994 and 1995 have been reduced by several percentage points through the carry forward mechanism.

A particularly troublesome provision of the revised cost principles relates to "departmental administration" and was widely interpreted to require that clerical and administrative salaries be charged as indirect costs except where special circumstances existed on major projects. At the close of the year, an interpretive letter from OMB appeared to respond to the arguments of...
the university community that traditional single investigator research projects require various forms of clerical and administrative support which should be permitted when they meet the definition of "direct costs" and certain other criteria.

Another consequence of the revised cost principles is that the salaries of UROP students are, effective July 1, 1994, subject to the application of indirect costs. This will substantially increase the cost and reduce the incentives for employing UROP students on research projects. In order to maintain the level of UROP students engaged in on-campus research, the Provost committed Institute funds to offset the additional cost for the 1994 summer UROP program.

Research Assistant Tuition
As noted in last year's report, OMB has reached the decision that MIT and three other major research universities will not be permitted to continue charging the tuition of graduate student research assistants to the employee benefit pool but will be required to treat it as a direct cost to the individual research projects on which they are employed. The implementing regulations are set forth in the revised OMB Circular A-21 and provide a transition period which will result in MIT treating tuition as a direct charge for RA appointments commencing in 1998.

Conflict of Interest
Shortly after the end of the year, PHS issued its long awaited proposed rules on conflict of interest and invited comment from interested parties. Although earlier drafts had addressed conflicts arising from clinical studies and evaluations of commercial products, the rules as proposed would apply to all PHS funded research. Additionally, PHS asked for comments on whether they should apply to institutional as well as individual conflicts. In its reply, MIT urged that institutional conflicts not be covered by rules designed to deal with individual conflicts and also recommended a number of modifications intended to further clarify and limit their scope.

At the same time, NSF issued its own conflict of interest rules, to be effective June 28, 1995, as a revision to the NSF Grants Policy Manual. Although the NSF rules are generally consistent with those issued for comment by PHS, a number of universities are recommending additional changes to the PHS rules to reduce the inconsistencies which remain.

Technology Reinvestment Program
Last year we reported on the substantial amount of proposal activity generated at MIT by the Technology Reinvestment Project (TRP), which is being coordinated by the Advanced Research Projects Agency (ARPA) on behalf of six Federal agencies. That activity involved proposals being submitted for a deadline on July 23, 1993. As a result, MIT received six awards, including one to Lincoln Laboratory. Since then, a variety of proposals have been submitted by MIT in response to solicitations for focused research projects as well as broad program announcements issued by various DOD agencies. At year end, it was also anticipated that the general announcement for the 1994 TRP program would be made shortly.

In many cases, the statutory authority for these programs provides for contracting mechanisms other than the traditional grants, contracts and cooperative agreements with which both universities and industrial contractors are familiar. In addition, programs which involve university/industry partnerships require the negotiation of various types of teaming and collaboration agreements. These, in turn, often require extensive negotiations relating to dissemination of information, intellectual property rights, and the transfer of resulting technology. This type of contracting has and will continue to require an increasingly specialized staff in OSP; close coordination between OSP and other MIT offices, including Technology Licensing and Corporate Relations; and greater interaction between MIT researchers, their industrial counterparts, and Federal program monitors.

The Bayh-Dole Act
Last year, we reported various threats to the vitality of the Bayh-Dole Act, which established a single uniform patent policy permitting universities to retain ownership of inventions resulting from Federally funded research, subject to certain requirements in the public interest. That Act triggered the substantial and continuing expansion of university technology transfer activities which is evident not only at MIT but at virtually every major research university. Last year we cited various threats, including a decision of the National Institute of Standards and Technology, within the Commerce Department, that universities could not own patents resulting from research conducted under the Advanced Technology Program, which is a major and expanding source of funding for technology transfer programs designed to enhance the nation's competitiveness. Although an amendment which would negate that decision has been included in pending legislation, it was unclear at year end whether or when that legislation might go forward.
Information Systems (IS) is an MIT service organization whose primary purpose is to enable individuals committed to education, research, and service to use information technology more productively in their work. IS strives to accomplish its mission through the interaction of two basic elements — people and technology — in four strategic areas: the information technology commons, academic computing, administrative computing, and research computing. This year IS staff contributed in all these areas, working with others throughout the Institute community on activities managed both within and across the six IS departments. This report presents an IS overview; the department reports that follow describe specific accomplishments.

Today, faculty, students, and staff use all the basic layers of MIT's information technology infrastructure, which has truly become a commons. The commons includes the 5ESS phone system of some 16,000 lines; the campus network which connects over 8,000 campus-based computers; and many services, ranging from the sale and repair of desktop devices, through training, to electronic mail, voice mail, and campus-wide information. One IS strategic objective is to make computing and telecommunications ubiquitous, transparent, and accessible for everyone in the Institute community. IS completed major steps toward this goal this year. Of the 470 network installation projects, the largest was introducing service to the independent living groups (ILGs) and the undergraduate dormitories. Network availability in graduate residences will begin in September 1994, when MIT telephone service will also extend to Tang Hall and Edgerton House. Similar service to Eastgate and Westgate will begin in August 1995. In its tenth year, the MIT Computer Connection added new hardware product lines from AT&T and Silicon Graphics, as well as an array of software.

Academic computing has become an essential component of the Institute's educational experience. IS staff operate the Athena computing environment, and they help faculty and students use existing technology effectively. Investment in Athena hardware renewal, in software development, and in third-party software aim to continually improve the availability of educationally useful services. No matter how it is measured, demand for Athena and related services continued to increase this year. Public clusters, for example, operated at full capacity, despite network availability in dormitories and ILGs. At the Provost's request and with funding from his office, IS delivered laptop computers to faculty in Humanities and Social Science and in Architecture and Planning. A growing number of faculty interested in educational computing inspired new instructional uses of Athena, such as multimedia, widespread use of on-line handouts and the Online Teaching Assistance (OLTA) service, expansion of on-line Japanese services to new subjects, and an enlarged suite of third-party software. Electronic classrooms and other instructional facilities were expanded and upgraded. The partnership between IS and the MIT Libraries in the Distributed Libraries Initiative brought additional electronic library services to the campus.

MIT's resources for administrative computing include staff in all the other central service areas as well as in IS. Administrators are customers of the commons and use applications supported by central offices. In addition, IS staff operate the W91 Data Center and develop and support administrative applications and databases. Led by IS, a team with staff from IS and other offices developed a shared vision and set of basic precepts for a campus-wide administrative computing architecture. A data administrator position was defined and staffed, supported by a newly formed advisory group, to address coordination of and access to Institute data. Working with the Institute's Administrative Advisory Committee, staff from IS and other central offices prepared a consolidated directory of administrative computing services and produced a forum for administrative officers. Applications such as the HASS-D Lottery program, enabling students to select HASS-D subjects using Athena workstations, demonstrated the usefulness of MIT's distributed computing environment for administrative work.

As the use of information technology becomes pervasive and its capabilities expand, once distinct boundaries separating academic, administrative, and research computing disappear, especially for the growing number of individuals at MIT who compute to support their multifaceted roles in education, research, and administration. Blurring of boundaries began years ago for research computing, which IS supports primarily through services of the information technology commons, such as the campus network, discounted hardware maintenance, and subscriptions to system software libraries. Working across boundaries is a vital element in academic computing, where technological and interpersonal collaboration within and beyond IS is critical for meeting instructional priorities. In the year ahead, the Institute must create similar coherence among administrative computing resources in order to enable and sustain the simplification of its administrative processes.

JAMES D. BRUCE
Academic Computing Services

Academic Computing Services (ACS) seeks to improve MIT education through the effective use of computers and other information technologies. ACS provides direct support to faculty members interested in instructional computing, acquires and deploys third-party software for faculty and student use, and hosts hundreds of visits from individuals and organizations worldwide interested in MIT academic computing services. Working with other Information Systems groups and with academic departments, ACS develops, deploys, and maintains public and departmental computing facilities, including the Athena Computing Environment. Through advocacy, training, documentation, and consulting services, ACS and its collaborators support instruction in individual subjects, individual academic work, and extensive communication among faculty, students, and staff.

Several milestones made 1993–94 extraordinarily productive for academic computing at MIT.

• ACS continued to attract new instructional use of Athena. This included diverse uses of World Wide Web services, including multimedia; continued expansion of on-line Japanese services to new subjects; new uses of Maple and Matlab in diverse subjects; and widespread use of on-line handouts, Online Teaching Assistance (OLTA), and similar instructional-management services.

• At the Provost's request and with funding from his office, ACS selected, purchased, configured, and delivered laptop computers to almost all members of the Humanities and Social Science faculty and the Architecture and Planning faculty. ACS also provided training and consulting to the recipients.

• ACS continued to enlarge the suite of third-party software available to Athena users. In addition, ACS upgraded a wide array of current third-party software and arranged for the Oxford English Dictionary to be available on Athena by the fall of 1994.

• ACS expanded and upgraded electronic classrooms and other instructional facilities, adding two lecture halls with Athena workstations and video projection (26-100 and 3-133) to the existing two, and began planning for a fifth electronic classroom (E53-220) to open in February 1995, in partnership with the MIT Libraries.

• Systematic renewal of Athena equipment continued. ACS replaced hundreds of workstations with faster, color workstations after an extensive competitive-bidding process. All public Athena workstations are now very capable machines, with the departure of the last public VAXstation 3100 and PC-RT computers.

Two important values continue underlie academic computing at MIT. One involves collaboration and organizational boundaries; the other involves academic priorities.

Collaboration and organization. Academic computing at MIT comes primarily from four sources: departments, labs, centers, and faculty members; students and their living groups; a few freestanding providers; and three departments in Information Systems (ACS, Computing Support Services, and Distributed Computing and Network Services). Interconnections among the organizations can only work if everyone values collaboration over competition, openness over turf. At the same time, few problems in academic computing respond to one-dimensional solutions. In general, problems arise from complexity, and require complex solutions. Complex solutions require teamwork. And so ACS commits itself to organizational and individual collaboration.

Academic priorities. Allocating limited resources among continuing and new activities becomes an ongoing, delicate series of risks. The broad distribution of our activities largely reflects our commitments to existing services and projects. Changes in our activities for the most part reflect new requests from faculty. A set of four principles help us choose among competing demands for resources. All else equal, we prefer initiatives that

• Serve many students, rather than few;

• Serve the core of the MIT curriculum, including General Institute Requirements and large introductory subjects in popular departments, rather than its periphery;

• Seek innovation and creativity, rather than simple automation of traditional approaches to education; or

• Increase technological equity among departments, rather than inequity.

These principles have already affected equipment renewal and electronic-classroom allocations, and they have begun to affect support for faculty and graduate students. They will influence more activities as time passes.

GREGORY A JACKSON
During the past year, Administrative Systems Development (ASD) expanded application development, database support, and technical writing and training services in support of more administrative units at MIT. ASD launched and led the cross-Institute Administrative Computing Architecture team, chartered to establish a technical direction for administration computing at the Institute. ASD worked closely with Distributed Computing and Network Services (DCNS) to provide business applications for departments which support students. In addition to providing better services for students and administrators, these joint efforts have allowed team members to enhance their current competencies with distributed computing skills.

Throughout the year, ASD continued its shift toward a team-based organization with managers as coaches. The ratio of managers to staff is now set at approximately one to fifteen. Project management and project budget accountability has been shifted to team members. To make this philosophical shift possible, ASD continues to invest heavily in staff development, focusing both on formal training and on mentoring programs.

A budget reduction of $400,000, necessary to assist in reducing the Institute's deficit, resulted in the layoff of five staff and the elimination of two open positions, for a total reduction of seven positions. During the year, ASD began the challenging process of rebuilding an organization devastated by these layoffs. With assistance from outside team-builders and through the efforts of the staff, ASD has established new and different levels of trust within the organization. Staff members understand that they are responsible for their own individual development and for the overall success of the department. ASD is committed to ensuring that staff skills stay current and that staff are employable here as well as elsewhere in the industry.

Accomplishments:
- Led an Institute-wide administrative computing architecture effort, in collaboration with other Information Systems departments and business partners. Developed a shared vision and set of basic precepts for administrative computing. Defined and implemented the role of a data administrator and of an Institute-wide advisory group to address coordination of MIT data issues. Developed prototypes of a data warehouse and repository and conducted evaluation of end-user tools — all to improve access to data.
- Expanded the scope of Database Services by adding Sybase to its suite of supported databases.
- Created the AO data model, one portion of the enterprise data model. Began developing the data warehouse. Secured approval from the custodians of Personnel and Purchasing data to convert and load data into the warehouse. The data model will continue to be refined and expanded.
- In a joint undertaking with DCNS and the School of Humanities, developed a lottery system for students to select HASS-D classes via an Athena interface. In the first run of the lottery, 92.8% of the students received their first choice.
- Delivered a conference management system, for use by members of the Plasma Fusion and EECS groups. It is being used to support a national Superconductivity Conference.
- A new application for the Summer Professional Programs handles mailing lists and registration functions, including invoicing, payments, and refunds. This system, in use for the summer 1994 session, has helped the office to streamline its business procedures.
- Developed an application for the processing of math diagnostic testing results for freshman. It was first run in production during R/O week, fall 1993.
- Delivered an enhanced release of the Labor subsystem of the Physical Plant System. Completed analysis work and some of the coding for the new Accounting and Utilities subsystems. The completion of these subsystems will provide Plant with a fully integrated application.
- Implemented integrated project teams and project management tools and techniques to improve the quality, delivery, and accuracy of project budgets and schedules.
- Invested heavily in training: UNIX, C, data administration, data warehousing, multiple databases technologies, object technology, and project management, in order to build confidence and competency.
- Completed a hardware update program for staff to improve their overall productivity, enhance their skills set, and to ensure that they have the tools to develop the appropriate solutions for our customers.

KATHLEEN R. CIBOTTI
Computing Support Services

In FY 1994 the mission of Computing Support Services (CSS) continued to be the delivery of exemplary end-user support to Institute faculty, students, and administrative and research staffs. Services include sales and service of computing equipment; training, consulting, and publications; and software license evaluation and distribution.

CSS has built and maintains an enthusiastic, dedicated professional staff by promoting career development and team goals. In FY 1994, CSS expanded products and services to the Institute through its five teams.

MIT Computer Connection (MCC). In its tenth year, the MCC reached its third highest revenue total, $11.6 million. Unit sales were 2,795, the second highest total in its history. Inventory is managed with precision, with six turns of inventory this year and negligible shrinkage or obsolescence. Adding to its Apple, IBM, Dell, DEC, and Sun product lines, the MCC signed new resale agreements with AT&T and Silicon Graphics. In FY 1994, the MCC also incorporated the products and services formerly offered by CSS Software Acquisition, including the distribution of AutoCAD, FrameMaker, Maple, and Mathematica. The MCC continues to sell aggressively priced Athena workstations through the Purchasable Workstation Program, as well as products recommended for student use in connecting to MITnet from dormitories and independent living groups. The MCC reorganized its consulting and purchasing groups this year, forming them into two teams focused on high-volume stock sales and special orders, including UNIX workstation and volume-licensed software sales.

Consulting. Consulting provides Macintosh, DOS/Windows, and Athena technical support, consulting, and user-account services to the MIT community. Help is provided electronically, by phone, and in person. Consultants encourage clients to become more self-sufficient by developing self-help resources, user groups, local experts, and other outreach programs. The CSS Access Technology for Information and Computing (ATIC) Lab provides adaptive technology recommendations and solutions.

Computer Services (CS). Computer Services is a support organization for users of DEC, Sun, and Silicon Graphics workstations and a repair facility for Apple and IBM PC computers and Hewlett Packard printers. CS provides key hardware and software support services to a diverse constituency on campus, at Lincoln Lab, and at other remote sites. During FY 1994, CS provided discounted hardware maintenance for approximately 1,000 Athena CPUs, 340 DEC CPUs, and 80 Sun CPUs through outsourced contracts. In its own service center, CS did about 2,500 repairs and installed approximately 1,200 hardware upgrades. CS provided software updates and technical help for 800 DEC CPUs and more than 500 Sun CPUs. During FY 1994, CS launched two new programs: MITCare, a low-cost maintenance contract for microcomputer equipment, and the Silicon Graphics Varsity program, which provides discounted software and hardware maintenance for Silicon Graphics workstations. FY 1994 revenue for CS is forecast at $1.7 million.

Training and Publication Services (TPS). Over 2,000 community members attended TPS hands-on courses and used self-paced materials during Training Lab open hours. Noontime seminars and Quick Start sessions, with new FileMaker and TechMail classes, drew another 3,000 participants. Close to 5,000 students attended minicourses on 12 Athena topics. Evening workshops were offered to MIT faculty who received laptops. Publication initiatives included Health and Safety Guidelines for Computer Use at MIT (with the Repetitive Strain Injury Task Force); the Welcome to Athena for Faculty booklet for new faculty and TAs; MITnet Comes to the Dorms for students getting network connections; and Getting Started guides for new Athena software, including FrameMaker and Tecplot. TPS published ten issues of the i/s newsletter, including two inserts on IS services and administrative computing resources. The group began to investigate providing electronic versions of IS documents. In the past year, TPS documents won five awards from national professional organizations.

Director's Office. The Director's Office continued its role of coordinating services throughout CSS, ensuring accurate and timely reporting on all businesses and management of the overall CSS budget and resources. The Director's Office also reviewed, negotiated, and approved vendor software license agreements, in conjunction with MIT's Intellectual Property Office and the Department of Purchasing and Stores.

DANIEL M. WEIR
Distributed Computing and Network Services (DCNS) works with other Information Systems departments to provide campus-wide information technologies that serve the MIT community. DCNS has operational responsibility for key elements of MIT's distributed computing infrastructure:

- MITnet, the campus-wide computer network.
- The Athena Computing Environment, including software development and systems administration of servers, public clusters, and workstations in private offices.
- A common set of network services for selected UNIX, Macintosh, and DOS/Windows platforms.

Demand for DCNS services continued to grow by almost every visible metric this year. A few examples:

- The number of computers on MITnet grew to over 8,000 (a 25% increase). Traffic on the network backbone (in terms of average kilobytes per day) increased this year by over 70%. On an average day, the network delivers over 100,000 electronic mail messages (100% growth) through centrally administered servers.
- DCNS coordinated over 470 network installation projects (a 20% increase), including over 2700 Ethernet connections and installations in the undergraduate dormitories, Biology, Materials Science, and Libraries.

DCNS took major steps toward achieving its long-term goal of universal network access for all the MIT community. With Telecommunications Systems, significant milestones reached during the year included:

- Resnet installation. In spring 1993, the Provost approved funding to extend MITnet to undergraduate student residences. Service was implemented in independent living groups (ILGs) in September 1993 and to undergraduate dormitories in January 1994, and to graduate dormitories beginning in September 1994.
- MITnet dial-up access. DCNS launched a project in December 1993 to develop a service to provide dial-up access to MITnet from off-campus via PPP and ARA protocols. Availability is targeted for late 1994.

DCNS continued operation of the Athena Computing Environment. In collaboration with Academic Computing Services and Computing Support Services, major initiatives included:

- Athena equipment renewal and maintenance. During the summer and fall of 1993, DCNS replaced hundreds of obsolete workstations, printers, and servers in public, departmental, and private facilities, and began a new workstation self-maintenance program, significantly reducing maintenance costs and repair time.
- Athena software. DCNS released a version of Athena for Sun's Solaris operating system. New versions of Athena for Digital's Ultrix and IBM's AIX operating systems were also released this past year.
- The HASS-D Lottery program, a joint undertaking of DCNS, Administrative Systems Development, and the School of Humanities, enabled students to select HASS-D subjects from Athena workstations.
- Athena public clusters. DCNS formulated initial plans to make Athena workstations in public areas accessible to special needs students. The first project will improve wheelchair access in three clusters.

DCNS value-added network services continue to be strategically important. This year's initiatives included:

- New products. TechMail for Windows and MacOLX (Athena on-line consulting service) were introduced.
- Distributed Library Initiative. With the Libraries and the Office of the Vice President for Information Systems, work continued on an effort to improve electronic library services available over MITnet.
- Campus Wide Information System (CWIS). Building on the success of TechInfo and new Internet technologies such as the World Wide Web, DCNS worked with other IS groups to complete a long-term strategy for MIT's on-line public information service. A CWIS facilitator will be appointed in July 1994.

DCNS is part of a space study, initiated by the Planning Office, to provide near-term relief for groups affected by the bridge between the new Tang Center and Building E40. Some options involve moving DCNS and E40 facilities, including the primary Athena computer room, no later than June 1995. Should this occur, the implementation of such a move would have major, unplanned impact on DCNS activities in the coming year.

Finally, I am pleased to report that MIT received an honorable mention in the 1993 CAUSE award for Excellence in Campus Networking.

CECILIA R. d'OLIVEIRA
Operations and Systems

The mission of Operations and Systems (O&S) is to provide a central computing facility and technological leadership that deliver efficient, high-quality computing services in a distributed computing environment that supports the Institute’s business needs. O&S activities can generally be categorized as installation, maintenance, systems integration, and client support. O&S offers general purpose computing on one large IBM computer, and our services include support for products across multiple platforms including VAXes and Macintosh and IBM personal computers. Additionally, O&S provides facilities management services to Institute departments to assist them in maintaining dedicated computer systems. Areas supported under such arrangements during the past year include Accounts Payable and Purchasing, Administrative Systems Development (ASD), Budget Office, Libraries, MIT Supercomputer Facility, Physical Plant, Property Office, Registrar, and Telecommunications.

Selected accomplishments which had a direct impact on O&S clients include:

- As part of our core business, O&S kept the system up and running 99.8% of the time; responded to over 7,500 help-desk calls; ran 30,000 production jobs, mounted 120,000 tapes, and printed 200,000 files for a total of 14 million pages.
- To increase system performance and availability, the operating system for the IBM mainframe was migrated from VM/HPO (High Performance Option) to VM/ESA (Enterprise Systems Architecture).
- To provide adequate capacity, reliable service, and reduced maintenance, new equipment installations requested by clients included:
  - A DEC VAX 7610, to replace a DEC VAX 8550 for the Comptroller’s Accounting Office and Purchasing.
  - A DEC VAX 4000-100, to replace a DEC VAX 8530 for Physical Plant.
  - A DEC VAX 4000-100, to replace a DEC VAX 4000-200 for ASD.
  - A DEC VAX 7630 and a VAX 4000-100, to replace a DEC VAX 6510 for the Registrar.
- To provide improved backup service at lower cost to VAX clients, O&S migrated to high-bandwidth cartridge tape drives.
- Automated operations efforts continued as a strategic approach to provide improved service with limited resources. Significant progress was made during the past year in message handling, and an automated notification system has been evaluated and purchased.
- To ensure a continued high level of digital dial-up connectivity to the mainframe, a cross-functional team evaluated over 15 products to replace a marginally supported Ascend Pipeline X.25 multiplexor. A cost-effective solution was identified (ATT Packit/30), and replacement of the older equipment has begun.
- Efforts to provide for business continuity for MIT’s critical computer applications continued. A successful test of the Admissions system was held in September 1993, and O&S helped Lincoln Lab develop their disaster recovery plans.
- Tape-related production job failures were reduced by 90% through an effort to identify and replace several hundred poor quality tapes on behalf of IBM and VAX clients.
- A new service (ADSM, ADSTAR Distributed Storage Manager) that provides backup, archive, and recall of data files for workstations and personal computers was introduced. ADSM is available to all staff and students with access to MITnet.
- To help the Institute reduce its mailing costs, O&S announced a new service that will allow clients to correct their electronic mailing lists and take advantage of postal discounts.
- O&S continued its involvement in Total Quality Management (TQM) in Information Systems as facilitators and participants in Quality Improvement Teams.
- Significant work was done in partnership with other areas (including ASD) on the administrative computing architecture project and with the Libraries on their new system.

ROGER A. ROACH
Telecommunications Systems received approval to extend MIT 5ESS telephone service to graduate student houses. The 5ESS wiring infrastructure will enable MIT to extend campus computer network service (Resnet) to graduate houses. Telecommunications Systems has begun cabling, wiring, and other related work. The department plans to provide telephone service to Tang Hall and Edgerton House in August 1994, with service to Eastgate and Westgate to follow in August 1995.

Working with Distributed Computing and Network Services, Telecommunications Systems implemented Resnet in the campus undergraduate houses. Telecommunications provided digital connectivity to MITnet to all the independent living groups (ILGs) via frame relay service provided by NYNEX. Frame relay, a data communications service based on packet-switching technology, enables 56 Kb/s connections between the ILGs and the campus data network.

Telecommunications Systems provided telephone service to students residing in Huntington Hall, 620 Huntington Avenue, Boston. Access to local, long distance, and MITnet services is provided by two digital T-1 circuits to the MIT 5ESS system.

The Northern Telecom SL-1 PBX at Bates Linear Accelerator (LINAC) was upgraded by installing a new processor, memory packs, reserve power, and the current software release (release 19 — a change from release 1, which was installed in 1977). The LINAC telephone network was reconfigured to support direct inward dialing of incoming calls, and telephones were assigned MIT telephone numbers beginning with 253. All inbound calls will now be routed from the switched message telephone network to individual LINAC telephones via new digital tie trunks between the campus and LINAC.

Telecommunications services were provided to the occupants of the new Biology building as well as to Center for Transportation Studies located in 3 Cambridge Center.

Working with the Industrial Liaison Program and others, the department provided telecommunications facilities and services for the Industry Summit held at MIT, September 9-12, 1993.

Telecommunications Systems revised the current long-distance agreement with AT&T, and extended it to June 30, 1997. The new agreement becomes effective on July 1, 1994, and will reduce long-distance usage rates. This change will generate annual savings to MIT and the Lincoln Laboratory of $135,800 in the first year. In addition, MIT and Lincoln will share in a credit of $262,500 towards usage beginning on July 1. MIT also has a working relationship with MCI which includes routing of inbound telephone traffic from MCI directly to MIT. MIT received in excess of $61,000 in revenue from MCI under this relationship.

The department entered into an agreement with Continental Cablevision to extend commercial cable service to MIT community via MIT Cable Television (CATV). Approximately 30% of the campus residential community subscribed to Continental Cablevision service.

Working with the Comptroller’s Accounting Office, Telecommunications Systems initiated changes to telephone billing to reflect revisions to OMB Circular A21.

Telecommunications Systems placed orders with AT&T to enlarge the capacity of the MIT 5ESS. In addition, the department plans to upgrade current generic software to newer versions and to revise the MIT dial plan.

MORTON BERLAN
INTRODUCTION

This report covers the second year following the successful conclusion of the Campaign for the future on June 30, 1992. The planning for the post-campaign period began during the final years of the Campaign and resulted in a rather rapid adjustment to new priorities and programs. The objectives for the post-campaign include a high priority on the retention and training of staff and a focus on priorities and key prospects that had not been developed. It has also been a time to reorganize the staff to more effectively increase commitments and gifts. These efforts include activities that will prepare the organization and the Institute for the next major fundraising initiative, probably in the second half of the decade.

During the past year, the staff has continued to carry a heavy workload, and by some measures, has been more active than in the final years of the campaign. This reflects both the planning by the staff and their increased experience and skills. The senior officers remain active in cultivation and solicitation of key prospects and major commitments were received. Coordination of fundraising efforts between the Alumni/ae Association and Resource Development, particularly in the reunion gift effort, has been effective and productive. We were also pleased that so many of our leading volunteers continued to participate in fundraising efforts.

Resource Development staffing continued to downsize over the past year reflecting the Institute's ongoing need to reduce operating costs. This included 1 layoff and the elimination of both staff and support positions. During the year there were 18 promotions (10 men including 3 minorities, 8 women). In addition, 14 open staff positions were filled by 6 men including 1 minority, and 8 women including 2 minorities. Thomas Moebus was appointed Director of Corporate Relations effective July 1, 1993, having served as acting director since the previous September. On June 1, 1994, President Vest named Barbara G. Stowe as Vice President for Resource Development, succeeding Glenn P. Strehle who became Vice President for Finance and Treasurer with responsibilities relating to financial operations. Ms. Stowe had served as Director of Foundation Relations since 1988 and assumed increased responsibilities for Development Services in 1991. Resource Development continues its effort to fill positions with qualified women and minority candidates, working closely with Personnel and others to identify new resources from which to draw applicants. The department participated again this year in the Case Minority Internship Program which added an African American woman to the staff in July 1994. Resource Development is committed to hiring and promotion goals set out in the Affirmative Action report filed with the Department of Labor in March.

Private Support

Private support for FY94 totaled $94.5 million, including the following: $86.7 million in gifts, grants, and bequests, and $7.8 million in support through membership in the Industrial Liaison Program. The total compares with $96.8 million in 1993, $97.4 million
530 Vice President and Treasurer

in 1992, $101.1 million in 1991, and $111.1 million in 1990. Gifts-in-kind for the past year (principally gifts of equipment) were valued at $7 million.

Sources of gifts for FY94 were: alumni, $28.5 million; non-alumni friends, $9.9 million; corporations, corporate foundations, and trade associations, $27.6 million; foundations and charitable trusts, $19.7 million; and others, $1.0 million.

Donors designated expendable and endowed funds as follows: unrestricted, $13.9 million; departments, $34.7 million; faculty salaries, $11.6 million; graduate student aid, $5.6 million; undergraduate student aid, $7.4 million; building construction funds, $3.6 million; and other funds, $9.9 million.

INDIVIDUAL GIVING

In FY94, the Office of Individual Giving, under the direction of George Ramonat, continued to perform its role of moving individual prospects (alumni and friends) through the donor development process (identifying, qualifying, cultivating that involves building strategies, soliciting and stewarding). During the year, ten field staff managed a total of 1,742 qualification, cultivation, solicitation and personal visits. Included in the above numbers is activity by the senior officers of the Institute who completed approximately 259 individual calls. These activities are managed by the major gifts staff and the director of principal gifts, utilizing alumni volunteers, faculty, deans and senior officers. It should be remembered that personal visits, in addition to events structured to cultivate and involve alumni and friends both on and off campus, are considered quality activities in the development process. Also integral to the quality of the activities is the support provided within the office by the communications and donor relations staff to the field operations.

Three new major gifts officers joined the field staff: John Landry, Major Gifts Officer for the Midwest and New England; Lorraine Alexander, Major Gifts Officer for New York Metro; and John Dresser, Associate Director of Major Gifts for Gift Planning. Meredith Thomas, who is responsible for the Great Plains, was promoted to Associate Director of Major Gifts.

Principal Gifts

During 1993-94 there were 13 solicitations of principal gifts prospects and 44 principal gifts prospects were visited by senior officers on a total of 57 occasions. These visits are included in the senior officer activity summary above. Lucy Miller, Director of Principal Gifts, also oversaw logistical arrangements for visits to individual prospects by the President on a two-week trip to the Far East and a one-week trip to Europe. In addition, she organized a groundbreaking celebration for the new Jack C. Tang Center for Management Education.
Communications and Donor Relations

Directed by Elizabeth Harding, this office has three main areas of responsibility: editorial support for fundraising; the coordination of fundraising-related events including campus visits; and the management of major gift stewardship at MIT.

The editorial group works with individual, corporate, and foundation staff to write and edit proposals, newsletters, direct mail letters, and brochures. The principal publication of the office is *Spectrum*, a 16-page tabloid newsletter which is distributed to alumni/ae, faculty and administrative staff. Other major publications produced in the past year included *MIT Facts*, three issues of *Parents’ News*, a Parent’s Handbook, a brochure for the Katharine Dexter McCormick Society, and eight donor profiles for the alumni/ae section of Technology Review. Theresa Pease, the Editor of *Spectrum*, left the Institute in June and was succeeded by Elizabeth Karagianis.

In the late spring it was announced that the Office of Sustaining Fellows and Special Events would be merged with the Office of Campus Visits into the Office of Events with Estelle Cashman named as Associate Director and Marsha Edmunds as Assistant Director. In the past year these two offices played a key role in organizing the annual Ivy-MIT-Stanford fundraising conference held on the MIT campus. Four campus visits were held with a total attendance of 129 guests, and over a dozen cultivation and stewardship events.

In the past year the Office of Student Financial Aid turned over the stewardship of over 120 scholarship funds to the Office of Donor Relations in the hopes that greater personal attention to these donors will increase the contributions made to the funds.

A recommendation made by a special task force to cease growing the Life Sustaining Fellows program was put into effect in the spring with a letter from Chairman Paul Gray to past Annual Sustaining Fellows. These fellows were offered a final opportunity to gain a Life Membership. Following the recommendations of the task force, a new committee was formed in May to review all central stewardship activities to assess how MIT could further strengthen the ties between the Institute and its top donor groups. The committee's report is expected late in 1994.

Corporation Development Committee

The Corporation Development Committee (CDC) held its annual meeting in November 1993. A highlight of the program was a dinner presentation by world-renowned economist Professor Rudiger Dornbush. The next day's meeting was devoted to interactive sessions designed to elicit the members' opinions about programs and strategies to be developed by Resource Development over the next few years. Key topics of discussion were the status of the Sustaining Fellows Program and the upcoming task of electronic and peer screening of the alumni/ae body. The last such screening program occurred in 1984.
The CDC Steering Committee met in May to plan the agenda for the annual meeting in November. Presentations were given covering the Alumni/ae Association's long range planning, the stewardship task force, new directions taken by Corporate Relations, and strategies for the mini-campaign for undergraduate financial aid.

**OFFICE OF DEVELOPMENT RESEARCH AND SYSTEMS**

Headed by Shelley Brown, the department focused its efforts on three major activities during 1993-94: implementing the new alumni/ae screening effort (called Building a Global Donor Base: The Next Generation); assuming administrative and programming responsibility for the gift system component of the Alumni/Development/Donor/Schools (ADDS) database; and creating and implementing (through training) a departmental "information fileserver." Each of these activities was based in one of the department's major functional areas and was carried out alongside standard operations.

The screening activities were managed through the research group in partnership with the Office of Individual Giving field staff. Formally launched at the annual meeting of the CDC in November, the screening effort has included nine screening sessions throughout major market areas and three sessions geared to reunion classes. The goal, over the next several years, is to identify new prospects capable of making a significant gift to the Institute. So far over 3500 prospects have been rated according to their giving capability, of whom almost half had no previous screening/rating. The research staff also continued to support the cultivation and solicitation activities of senior officers and field staff, providing backup on 350 prospects for senior officer attention and on another 600 prospects for the field staff.

This year the development information systems group assumed management of the ADDS database in partnership with the programming staff of the Alumni/ae Association. The transition in responsibility from Administrative Systems Development to the new partnership started in the early fall and was completed, in effect, in June, when the year-end processing was handled fully by the two staffs. The group produced about 500 ad hoc reports over the year and completed the first phase of information engineering training which will lead to a major systems redesign effort over the next 3-5 years.

The group supporting the department's macintosh network designed the information fileserver to facilitate intradepartmental communication. They were also closely involved, along with the systems group, in the design and implementation of the screening effort and in the production support of departmental events, new programs, and mailings. This year they completed the final phase of a four-year equipment upgrade plan.

During the year, Lisa Donovan and Cathleen O'Shea were promoted to Assistant Director and Senior Research Analyst, respectively. In addition, three research analyst positions were filled. Gregory Whall left the Institute after fourteen years to pursue graduate studies.
FOUNDATION RELATIONS AND DEVELOPMENT SERVICES

Directed by Barbara G. Stowe, support from private foundations for FY94 totaled $19 million, continuing to make a significant contribution to MIT's educational and research programs. Major grants or pledges were received in support of neuroscience research, graduate fellowships in Civil and Environmental Engineering, industry-based studies, as well as for a seminar series for congressional staff and for MIT's Minority Summer Research Program. The open position of Senior Research Analyst was filled in the fall. The group's associate director, John S. Wilson, has assumed the role of acting director of Foundation Relations, following the appointment of Ms. Stowe as Vice President for Resource Development.

The Office of School Development Services (OSDS), directed by John Wilson, continued to pursue its mission of facilitating school-based development activities in tandem with the school development officers, the deans, faculty and the Office of the Provost. The demands on the office increased only slightly this year in part due to the absorption of several key administrative changes, including the arrival of two new deans and two new school development officers, and the departure of one school development officer.

The staff's support of various initiatives during FY94 was vital to the funding of key projects within each of the schools. For instance, in the School of Engineering OSDS assisted in developing support for four chairs and three funds. Efforts with the School of Science focused in part on developing stewardship/cultivation events involving major donors, and handling a number of prospect screening projects to identify new prospects for several fundraising projects in the School. OSDS assisted in the strategizing and marketing of the Sloan School's major fundraising initiatives including the Tang Center for Management Education, the Trading Room, and their Pacific Rim ventures. Efforts with the School of Humanities and Social Science focused on expanding support for the World Economy Lab and the Economic Council. Work with the School of Architecture and Planning and its new dean emphasized identifying new corporate prospects for the design studios, developing new programs to engage the School's alumni, and investigating new donor prospects in Asia.

Finally, OSDS continued to provide support for initiatives under the Provost, including planning fundraising trips, and assisting with the Environment Initiative and the K-12 Program. Fundraising with the MIT Libraries focused on developing support for the Distributed Library Initiative, a major new program.

CORPORATE RELATIONS INCLUDING INDUSTRIAL LIAISON PROGRAM

Thomas Moebus, Director of Corporate Relations, reports that the financial performance of both the Industrial Liaison Program (ILP) and Corporate Development improved somewhat this year. ILP revenues of $7.85 million were up 3.6% from $7.57 million in FY93. Higher revenue was obtained from 5 fewer companies (202 as compared to 207 at the end of FY93).
Corporate cash gifts to MIT totaled $27.6 million, up 6% from the prior year. Of this amount, Corporate Relations staff were directly involved in soliciting $13.5 million, up from $11.7 million in 1993. Programmatic support continued from the Leaders for Manufacturing sponsors, including phase two funding and the addition of two recent members. Support for the Joint Program on the Science and Policy of Global Change increased and payments on a number of outstanding pledges were received (TEPCO, Credit Suisse, AMP, and Exxon). The overall climate for corporate giving remains difficult.

Corporate Relations development activities were focused during the year through the assignment of additional resources and the implementation of a more formal prospect identification and tracking system. Corporate Relations staff continued to support faculty research funding efforts with corporations. Total research monies committed in which Corporate Relations staff were directly involved were $10.8 million, up from $7.5 million in 1993. The major pledge by Amgen, coordinated by Principal Liaison Officer Robert L. Malster, contained both gift and research components (a total of $30,000,000 over 10 years). Other new research contracts obtained included funding from Gillette, Coopers & Lybrand, and Raytheon.

In August 1993, Corporate Relations and the ILP launched an internal effort to better understand and improve customer relationships with the MIT faculty and industry. The project was motivated in part by suggestions received during the previous year from the ILP's Corporate Advisory Panel, as well as continuing discussions with the faculty Task Force on Industrial Linkages. The initiative became known as "IQ," based on the key concepts of Innovation and Quality. Using a team approach, the Corporate Relations staff undertook extensive interviews with MIT faculty and industry representatives utilizing voice of the customer techniques espoused in concept engineering and total quality management.

The results of the surveys have provided significant insight about the environments, needs, and measurements of success of our customers. The Voice of Faculty study has highlighted the demand for better coordination of MIT's interactions with industry, improvement in MIT's understanding of industry needs, as well as a better process for matching of research. The Voice of Industry discussions have identified that industry and university needs are yet to converge, and while the opportunities for targeted alliances exist, the competitive narrow profit environment of industry puts great pressure on outcome. Also identified was the need to better utilize emerging information technology in maintaining communication and linkages with corporations. The IQ^ effort will culminate in the merging of faculty and industry voices to create new products and services. To date, the conference development, marketing, and publications services have been reviewed to be in closer alignment with customer expectations.

Featured among the ILP's series of conferences and seminars last year was "Proactive Environmental Strategies for Industry," which was presented in conjunction with the MIT Council on Global Environment and the Program for Environmental Engineering, Education, and Research, and drew 115 managers from 66 companies. "Inventing the Organizations of the 21st Century," co-sponsored with the MIT Center for Coordination
Science and the Organizational Learning Center, was attended by 364 middle to upper level managers, representing 136 companies. A total of 169 senior research managers representing 91 companies attended the "Research Director's Conference: A Window on Emerging Technologies." Finally, the ILP co-sponsored with the Epoch Foundation of Taiwan, "The Globalization of Economy: Strategy for the Financial Services Industry." One component of this program was a videoconference presentation by one speaker from the MIT campus, in which a question-and-answer session was conducted with the audience in Taiwan.

During the last year, two staff members transferred from Corporate Relations to other departments at MIT and one left MIT to relocate. Cynthia D. Lubien, formerly Manager of Corporate Relations, assumed the position of Director of Development for the Harvard-MIT Division of Health Sciences and Technology; Paul E. Murphy, formerly Assistant Director for Administration, left to become Assistant Director of the MIT Center for Environmental Health Sciences; David Marsh, Manager of Corporate Relations, left MIT to relocate to another state.

Promotions this year included Carl A. Accardo and Robert L. Malster from Senior Liaison Officer to Principal Liaison Officer, and Susan I. Shansky from Manager of Communications Services to Assistant Director for Administration. Nine individuals were hired during fiscal 1994, (6 females including an Asian and a Black; 3 males including an Asian).

Glenn P. Strehle
ASSOCIATION OF ALUMNI AND ALUMNAE OF MIT

Association President Richard A. Jacobs '56 aggressively pursued the goals set up last year by the Long Range Strategy Committee (LRSC); two important activities of the committee included a telephone survey on alumni services, and the convening of a special subcommittee to compare the fund-raising structure of MIT to other similar schools. Many of the recommendations of the final report are already being implemented. These efforts take place concurrently with MIT's reengineering efforts.

MIT President and Mrs. Charles M. Vest (Rebecca) traveled widely for the Association, visiting alumni in several European cities. The Association’s executive vice president William J. Hecht '61 visited MIT Clubs in Tokyo, Hong Kong, Thailand, and Singapore in April. This trip included a meeting of Asian MIT Club presidents. Association President Jacobs made the Association's first official visit to the MIT Club of Brazil. Seven overseas Club presidents from Guatemala, Israel, Lebanon, Pakistan, and Venezuela attended Association Board of Directors meetings this year, filling the two at-large positions created for overseas representation.

The Association broke the all-time Fund dollar record with gifts of nearly $23 million (see below). MIT ProNet continues to be an active and effective job search service for MIT alumni. The Association continued to sponsor alumni interested in offering Independent Activities Period activities.

Leadership in the person of Association President Jacobs, Fund Chair Noel S. Bartlett '60, Ms. Laura T. Puckett, chair of the Enterprise Forum Board, Robert W. Mann '50 of the Technology Review Board, Mrs. Emily V. Wade '45 of the Awards Committee, and LRSC chair Robert A. Muh '59 continues to be the hallmark of the MIT alumni volunteer. The Association and the Institute are truly indebted to and strengthened by all of the volunteers who work on their behalf.

ALUMNI/AE ACTIVITIES

Alumni/ae Fund
Financial support from alumni, parents and friends, as measured by the Alumni/ae Fund, achieved record levels this year. With gifts totaling $23 million, the Fund dollar total eclipsed the old record by $1.8 million and exceeded the FY '93 Alumni/ae Fund by $4 million. Exactly 28,205 alumni contributed to this total, the greatest number of donors since 1989. Under the leadership of Mr. Bartlett and through the outstanding volunteer efforts of several thousand alumni, the Fund achieved all of its major goals and objectives. Especially gratifying was the 1,640 first-time gifts received mostly from recent graduates, the largest number of first-time gifts reported since 1985.

In the second year of separate goals for undergraduate and graduate alumni, both groups achieved their objectives for total number of donors and gifts of $100 or greater. 42 percent of undergraduate alumni contributed to the Fund, a one year increase of 2 percent. With 9,700 gifts from alumni whose first MIT degree is an advanced degree, the graduate alumni established a new donor record for the fourth consecutive year. Given the significant one-year increase in the number of donors, especially first-time gifts, it is noteworthy that upgraded contributions at significant dollar levels set new records.

Of special importance are gifts received from non-alumni parents. With a 25 percent increase in the number of contributions, the dollar total of more than $375,000 exceeded the previous Parents Fund record by 200 percent.

In addition to the several thousand alumni who participated in direct fund-raising efforts, there are an equal number of alumni who volunteer their time and energy serving as leaders of regional clubs and special constituencies, class officers, and many others. The outstanding results of the Alumni/ae Fund reflect the efforts of all those alumni whose collective interest in MIT encourage those less involved to participate in alumni activities.

Regional Programs
Regional Directors recruited 197 callers in 15 cities who contacted 3,340 alumni and raised over $439,000 this year. Telethons continued to be a significant source of income to the Fund; it must be noted that MIT leads all other universities in the nation in its number of volunteer alumni callers. A total of 178 alumni volunteered in
five Alumni/ae Fund Personal Solicitation Programs held in Boston, Philadelphia, San Francisco, and Washington, D.C.

Over 75 active MIT clubs around the world continued to provide alumni with meaningful venues to stay in touch with MIT and each other. This year, many clubs had unprecedented numbers of meetings, with the Club of Northern California topping the list with over 60 meetings.

Some highlights were: an elegant evening honoring MIT’s newest Nobel laureate, Philip Sharp, who was feted both at the President’s House and Barker Library by almost 200 Boston alumni and their guests; a “fireside chat” series initiated by the Club of Chicago which hosted local CEOs at receptions where young alumni could meet and network in an intimate setting; and invitations to the Israeli and Russian embassies by the Club of Washington, D.C., which were oversubscribed with over 100 alumni and guests attending.

Class Program

The Class Program provides support for the nearly 800 class volunteers, assists classes in planning reunion activities, and works with class gift committees to raise reunion gifts for MIT. Alumni/ae Week, with campus activities and class-sponsored events, is the centerpiece of the Class Program. This year 1,045 alumni from 13 reunion classes, from the fifth to the 70th reunion, returned to Cambridge for some part of Alumni/ae Week activities.

The Class Program is the principal Fund activity which focuses on undergraduate giving to MIT. Goals for undergraduate giving for FY ‘94 were exceeded this year with undergraduate donors reaching 18,475, of whom 53% made gifts of $100 or greater. These results represent an increase of 4.5% over FY ‘93 in overall undergraduate alumni donor participation after several years of declining participation in this area. Undergraduate classes support 88 class projects representing accumulated gifts to MIT of $29.8 million, of which $1.7 million are new gifts received in FY ‘94.

Class Program fund-raising includes reunion giving, class agent solicitations and stewardship, and the senior gift program. In FY ‘94 reunion gifts of nearly $30,000,000 were presented to MIT on Technology Day representing pledges from 4,335 alumni donors. More than 170 alumni volunteer solicitors contacted 1,200 classmates to ask for their support for MIT to achieve these results. Sixty-six class agents wrote solicitation letters and sent gift acknowledgments to members of their classes. The senior gift program recruited 42 solicitors who contacted 640 class members by phone, mail, and in person, for a record participation rate of 28%.

The 25th, 40th and 50th reunion gifts represent a total of five years of alumni giving and include pledges payable over five years. This year these gifts included $2.3 million from the 25th reunion class, including the establishment of the new Class of 1969 Scholarship Fund in honor of Paul E. Gray ’54, chairman of the MIT Corporation; $4.6 million from the Class of 1954, which included the creation of the Class of 1954 Career Development Professorship; and $6.15 million from the 50th reunion Class of 1944.

Other reunion gifts were also announced: from the Class of 1924, $3.9 million; Class of 1929, $3.6 million; Class of 1934, $2.5 million; Class of 1939, $2.6 million; Class of 1949, $1.4 million; Class of 1959, $710,000; Class of 1964, $1.2 million; Class of 1974, $102,000; Class of 1979, $102,000; Class of 1984, $51,000; and Class of 1989, $29,000. At Commencement on May 27, the Class of 1994 presented gifts and pledges of $44,000 to underwrite the installation of an information booth in the Stratton Student Center.

Class program innovations this year included a newsletter for class officers, Class Action, and a new class agent acknowledgment process which included the production of a quality thank you card. Many classes continued to offer class challenge funds, class recognition societies, and class premiums to encourage gift upgrading. One of the most successful of these was the MIT screen saver created for Class of 1964 members who increased their gifts by at least $35.

Involvement of current students is one of the most important objectives of alumni activities when one considers the future of alumni support for MIT. The Student Alumni/ae Council (SAC) is the vehicle created by students to provide a mechanism for this involvement. During the past year SAC produced an entrepreneurial program which included participation of undergraduate students, graduate students and recent alumni. Other SAC
activities included the annual St. Valentine's Day Dance, student ambassadors who worked during Alumni/ae Week, and the recruitment and training of 400 student callers for the Student Telethon in February. Senior Dinners at the President’s House, graciously hosted by President and Mrs. Vest, were attended by nearly half the members of the senior class and 24 alumni volunteers who welcomed members of the Class of 1994 to the body of MIT alumni around the world.

**Alumni/ae Week**

In addition to reunion class activities, attended by two thirds of the Alumni/ae Week registrants, the nearly 2,800 Alumni/ae Week attendees participated in a full program of activities June 2-5, 1994. The 1994 Technology Day Committee chaired by Jorge Rodriguez ’60, set the theme for this year’s Technology Day programs, "For the Wonder of It All: The Arts at MIT." This year the program extended throughout the weekend, beginning with Tech Night at Pops on Thursday, June 2. The Pops program included the performance of a work by Class of 1949 Professor John Harbison and played by Professor David Deveau on the piano; and the performance of Chairman Gray at the podium for the “Stars and Stripes Forever.”

The Technology Day program in Kresge Auditorium, led by Associate Provost for the Arts Ellen Harris, included presentations by Professor Emeritus Philip Morrison, celebrated architect I.M. Pei ’40, and Richard Polich ML ’65, president, Tallix Incorporated; and a conversation among area music critic Lloyd Schwartz. Professor Harbison, and Media Arts and Sciences Professor Tod Machover. The afternoon program included four sessions, offering theater, a sing-along, and information on the arts and architecture; these were organized and presented by MIT Professors Stephen Benton ’63, Alan Brody, Alan Lightman, John Oliver, and Dean William Mitchell.

In addition to the traditional Technology Day program, the committee offered tours of MIT’s art galleries and architecture on Saturday and on Sunday a performance of Love Letters was given by MIT faculty member and playwright Mr. A.R. Gurney, Jr. and Mrs. Kitty Carlisle Hart, a member of MIT’s Council for the Arts.

This year the popular Alumni/ae Barbecue and Games continued to attract large numbers of alumni and their families. The Saturday afternoon program featured a performance by Robin Right, Nashville recording artist; Texas two-step lessons taught by Sue and Herbert Norton ’64; and the third annual Alumni/ae Challenge Games, won this year by the tenth reunion Class of 1984. The Alumni/ae Games, created each year by a committee of alumni volunteers, chaired this year by Bonny Kellermann ’72, attract an increasing number of participants each year and are becoming one of the most popular events of Alumni/ae Week.

Other activities included the Memorial Service on Technology Day in the MIT Chapel, Sloan School reunion activities, Cardinal and Gray Society events, the Emma Rogers Society program, and a Black Alumni/ae of MIT (BAMIT) program, "Multi Media Educational Projects by People of African Descent," moderated by Professor Steven Lerman ’72.

**Special Projects**

**Homecoming**

The first MIT Homecoming in recent memory was held on October 23 with the theme “Mind and Muscle,” honoring MIT’s 75 scholar athletes. MIT President Emeritus Howard Johnson HM greeted the spectators during halftime of the football game and recognized the 25 scholar-athletes who attended from all over the world. It is the goal of this new student-alumni program to increase student loyalty to MIT and to provide a previously underutilized venue for alumni involvement, particularly for more recent alumni.

**Independent Living Group Support**

A three year capital campaign to raise $2,000,000 for the Independent Residence Development Fund (IRDF) was launched in November, 1993, under the leadership of volunteer chairman D. Reid Weedon ’41. The Alumni/ae Fund expected this campaign to increase participation and provide upgrading opportunities for the one-third of MIT alumni who had lived in independent living groups. At the end of the first year, gifts and pledges of $247,417 have been received; donors to the fund and annual gifts increased by 60%; the number of gifts ≥$1000 increased from 20 to 37.

Staff has also provided information for independent living group newsletters, event support for annual meetings and reunions, leadership training for volunteers, and advice for house specific fund-raising outside the Fund.
Friends of MIT Athletics
A Friends of MIT Athletics annual fund drive was initiated in January, 1994, which included a mail solicitation to nearly 10,000 alumni varsity athletes and two nights of volunteer telethons conducted by current athletes and coaches. Collaboration with the Athletics Department was excellent, resulting in $155,697 in gifts raised, a 31 percent increase in donors, and a 27 percent increase in gifts to MIT athletics. Eighty first-time donors made commitments to MIT through this new program. In addition to this project, the staff supported sundry athletic student-alumni events during FY ’94.

Black Alumnae of MIT (BAMIT)
The Ronald E. McNair Scholarship Fund exceeded the minimum for a fully endowed fund this year with a total of $153,000 in gifts since its inception. Established in 1978 as the BAMIT Scholarship Fund, it was renamed in 1986 in honor of Dr. Ronald E. McNair PH ’77, the black astronaut and MIT alumnus who lost his life in the space shuttle Challenger explosion. The McNair Fund is the only endowed Institute fund established and supported solely by contributions from black alumni.

The BAMIT Bulletin, a monthly publication listing job opportunities, as well as other BAMIT projects and events, was inaugurated with assistance from the Schools of Engineering and Science. In conjunction with the New England Board of Higher Education, BAMIT co-sponsored the second annual meeting of the Science/Engineering Academic Support Network for over 250 Black, Hispanic, and Native American high school students. Keynote speakers included Ms. Laura-Lee Davidson ’81, Associate Director, Quality Education for Minorities Network, Inc.; and Dr. Norman Fortenberry ’83, Program Director, National Science Foundation. The Office of the Provost provided substantial funds to support this effort.

About 60 minority seniors and their families attended the annual BAMIT Exit Reception for graduating seniors.

Association of MIT Alumnae (AMITA)
Each year, AMITA sponsors programs and events for MIT alumnae and women students. This year’s highlights included a mid-winter career networking dinner at the Wayside Inn in Sudbury, Massachusetts, with guest speakers Mr. Hecht and Mr. Robert K. Weatherall, Director, MIT Career Services Office; a pizza party during Residence Orientation week attended by over 200 returning and incoming women students; a brunch for undergraduate women with alumnae mentors representing careers in law, medicine, the environment and architecture; and a stress management workshop for women students led by Associate Dean Bonnie Walters.

AMITA has been an MIT organization for almost 90 years. Over that period, Institute funds and projects established by AMITA have included the AMITA Student Aid Fund, the AMITA Senior Academic Award for graduating women students, the Ellen Swallow Richards Professorship, and a new project, the AMITA Margaret MacVicar ’64 Memorial Oral History Project, a UROP project to document the lives of alumnae. The Oral History Project Fund now totals just over $70,000, toward a goal of $100,000. To date, 13 oral histories have been recorded in the MIT Archives.

Chinese Alumnae of MIT (CAMIT)
CAMIT observed its 10th anniversary in the 4692nd Lunar Year, the Year of the Dog. To celebrate, CAMIT held its annual Chinese New Year Banquet in New York’s Chinatown. Over 100 alumni attended and enjoyed a ten-course dinner. Professor Chi Fu Huang, the J.C. Penney Professor of Finance at the Sloan School of Management was guest speaker. The Boston chapter of CAMIT and the Sloan School’s Asian Business Club held a New Year’s feast at the MIT Student Center with Visiting Professor Yih-Jiam Tai of the MIT Chinese Language and Literature Program as guest speaker. CAMIT’s other activities included sending alumni representatives to the New York College Fair; hosting a reception at MIT for graduating Chinese seniors; and publishing a quarterly newsletter, CAMITalk, which features news synopses of interest to Asian alumni taken from articles published in The New York Times, Asian Week, The Economist, The South China Morning Post, and the World Journal.

Parents Program
The Parents Program introduced the Parents Guide to MIT to help undergraduate parents navigate their own trip through the Institute. The 1,800 guests at Family Weekend heard Professor Woodie Flowers ME ’73 discuss “technophobia” and were invited for the first time to attend their students’ classes. The Parents Fund continued to break records. With 445 gifts from non-alumni parents who gave a total of $375,800, it saw 35% growth in participation and 200% growth in dollars. Gifts from alumni parents raised the total to $989,000. A significant
factor in its success was a special letter to parents from President Vest, which, at 188 gifts, brought the highest response of all fund communications.

Alumni/ae Leadership Conference (ALC)
The 1993 Alumni/ae Leadership Conference, held on Saturday, October 2, was attended by over 400 alumni volunteers and their guests. Following the annual meeting of the Association, Association President Jacobs introduced Provost Mark Wrighton who set the context for presentations on “Getting an Education at MIT: What’s Changing?” Other speakers on the morning program included Dean Joel Moses MA ’67, Professor of Biology Eric Lander; Charles Mazel, Research Engineer, Ocean Engineering; and Dean Glen Urban of the Sloan School. Following the annual awards luncheon presided over by Association President Jacobs, sessions illustrating some MIT educational innovations were conducted by Professor Gene Brown, Whitehead Professor of Biochemistry; Associate Provost Harris, Professor Edward F. Crawley ’76, Aeronautics and Astronautics, Provost Mark S. Wrighton, and Mr. Gregory A. Jackson ’70, Director of Academic Computing.

Pre-conference workshops as well as board and committee meetings were held on Friday afternoon and evening. For the second year, the BAMIT annual meeting was held on this same weekend. New offerings this year included workshops for special interest group officers and for independent living group officers. Altogether, 221 alumni participated in the Friday activities, two-thirds of whom also attended the Saturday program.

Graduate Alumni/ae Program (GAP)

Solicitation Efforts
GAP closed another outstanding year of setting records and exceeding goals, showing a 4% increase in donors that resulted in a record high donor total of 9,730, an increase of nearly 400 donors over FY ’93. Giving at the ≥$100 level was maintained at 44%. New fund-raising initiatives and expanded joint efforts resulted in a turnaround in first time donors; among recent graduates, the first-time gift total was increased 13% to 441. Of the 22 active departments, 19 (86%) showed an increase in donors and 11 (50%) had a dramatic increase in dollars.

The annual fall solicitation appeals from department heads to their graduate constituencies raised more than $440,000 from 3,519 donors. The new paid caller donor acquisition telethon proved to be a major force in increasing first-time gifts to the Fund. During this five week program, 25 students phoned alumni who had never made a gift to MIT. Overall, 24 percent of the 4,800 alumni contacted made pledges. The efforts of 194 volunteer callers during the fall department telethons resulted in nearly $190,000 from 1,194 donors. The fall telethons were once again followed by a successful paid caller program geared toward LYBUNTS (gave last year but not this) and raised more than $32,000 from 484 alumni. Nearly 100 callers and their guests attended the third annual GAP volunteer appreciation reception and Omni Theater movie Beavers at the Museum of Science.

A restructured Personal Solicitation Program (formerly known as Alumni/ae Fund Visit Program) initiated two pilots: one for the Sloan School in Boston chaired by Leslie C. Hruby GM ’73 and Steven Somes, GM ’83, and one for graduate fellowships in San Francisco chaired by Harbo Jenson CM ’74. Both prototypes resulted in over 25 volunteer solicitors personally visiting alumni peers to secure upgraded gifts. In the San Francisco program, ten volunteer alumni solicitors contacted 41 prospects and raised $33,750. The Sloan masters initiative involved 12 volunteers who secured over $35,500 from 21 prospects.

Cultivation Efforts
GAP has continued to build partnership services and planning support for relational events with departments. This year, 13 receptions were held at regional meetings, including the American Institute of Aeronautics and Astronautics in Washington, D.C.; the American Institute of Architects in Los Angeles; the American Geophysical Union in San Francisco; the American Society of Mechanical Engineers in New Orleans; the Society of Naval Architects and Marine Engineers in New York City; and the American Physical Society in Pittsburgh. In all, 11 new cooperative initiatives, including events, newsletters, and alumni directories, were implemented totaling 33 collaborations throughout FY ’94.

GAP collaborated with the reunion staff to attract hundreds of graduate alumni to this year’s Technology Day activities. GAP also helped plan celebrations for the MIT/Woods Hole Joint Programs 25th anniversary which included dinner and a movie at the Museum of Science, and for the Technology and Policy Program Anniversary
Reunion of 1994. GAP teamed with the International Students Office to host a reception for graduating international students, their families, and their American host families at the MIT Museum on the eve of Commencement. Past Association president Christian J. Matthew ‘43 formally welcomed the students into the Association.

ASSOCIATION OF ALUMNI AND ALUMNAE AWARDS

Bronze Beaver Award

Lobdell Award

Kane Award

Morgan Award

Presidential Citation
Class of 1936 Chemical Engineering Practice School Group, MIT Club of Hong Kong, MIT Club of New Haven and MIT Club of Hartford, MIT Club of South Florida, Sloan Club of Boston

Honorary Membership
Charles M. Vest, John Preston

TECHNOLOGY REVIEW

The editors of Technology Review received a number of awards this year, reflecting growing acknowledgment of the magazine’s stature among other journalists as well as the wider public. Editor-in-chief Steven J. Marcus received the Award for Literary Contributions Furthering Engineering Professionalism from the Institute for Electrical and Electronic Engineers. IEEE cited his regular column in Technology Review as well as previous work as deserving of recognition. Mr. Marcus also participated in the process for selecting finalists for the National Magazine Awards, the most prestigious awards of the commercial magazine world. Senior editor Laura van Dam was a judge of the prestigious AAAS-Westinghouse Awards for science journalism.

Outside circulation of the magazine remained strong, complementing growing income from initiatives such as sales of science- and technology-related books to Review subscribers. Shortfalls in advertising, reflecting the still-uncertain business climate and fierce competition for advertising revenue, remained a problem. With the full support of the Review Board and the Association Board of Directors, the magazine has tackled this area for FY ’95 by hiring a second full-time sales representative and creating newly revamped supporting materials emphasizing the magazine’s national impact and its influential readers.

The MIT News section of the magazine launched a major redesign in an effort to serve alumni better, and is now testing higher-quality paper for the section.

MIT ENTERPRISE FORUM, INC.

The MIT Enterprise Forum has had a year of substantial change, the most important being the decision of national director Paul E. Johnson to take early retirement. Mr. Johnson has been associated with the Forum almost since its reformation, but felt that it was an appropriate time for him to move on. His last day was May 31, 1994. A search has been initiated for his successor. The leadership of the Forum Board has been critical in this year of change; special thanks are due to Ms. Puckett, who served with diligence and diplomacy as chair of the
Forum Board. The Forum is very grateful for the continued support of its national sponsor, Coopers & Lybrand, through this transition period.

Chapters of the Enterprise Forum offer start-up clinics, seminars, and business plan workshops. Corporate sponsors and registration fees provide financial support for chapter services. The hallmark of the Enterprise Forum is the “company presentation” where a CEO of a start-up company presents a business plan and concept to a panel of experts at a public session, who then offer comments.

Each chapter is formed around a core group of MIT alumni and is run by a volunteer board of professional entrepreneurs, corporate officers, university professors, and others. The governing boards of the chapters donate their time and services to individual companies seeking assistance and direction on the company’s operating, marketing, financial, and technological viability. While the chapters are formed around a core group of MIT graduates, the business services and professional analyses are open to anyone who chooses to join.

This year the new MIT Enterprise Forum of Hawaii was incorporated in early 1994, and the MIT Enterprise Forum of Israel was launched with an all day conference on “Success Factors in Technological Entrepreneurship,” which nearly 200 people attended. The Forum’s fourth technology transfer conference was held in Dallas, Texas, on May 15-17, 1994. The Forum also sponsored leadership forums for the Young Entrepreneurs Organization with Inc. Magazine in October, 1993, and May and June, 1994.

ADMINISTRATIVE INFORMATION SERVICES AND RESOURCES (AISR)

AISR was chartered to deal with all internal and external information needs of the Association and to integrate the office automation strategy with the alumni database. This year Alumni/ae Records enjoyed its best year in communicating with MIT alumni. An electronic mail address was offered to serve alumni better; through it, over 7,000 e-mail addresses and over 2,500 new address changes in less than a year to update alumni records. AISR also purchased a CD-ROM PhoneDisc system that allows the office on-line access to residential and business addresses and telephone numbers, replacing manual lookup in old telephone books. 79,000 questionnaires were mailed and over 28,000 returns were processed in order to produce the 1994 Alumni/ae Register.

Future computer needs will be met using a new technology called client-server. Nearly five months were spent evaluating different hardware and software vendors to determine the most efficient and cost effective systems available.

AISR is in the process of designing an e-mail server using FirstClass, an advanced conferencing, electronic mail, bulletin board, and on-line communication system with a graphical user interface for both the Macintosh and Windows environments. 75 beta testers are participating, including alumni volunteers, and another 500+ users are expected to sign on over the next year for a nominal fee. This will remain on beta status for the next year while FirstClass services are expanded.

Alumni/ae Travel Program

The Alumni/ae Travel Program continues to attract a wide variety of travelers. This year the 27 trips offered were taken by 373 travelers. These ranged from a Vermont bike tour to a trip through the ancient Chinese Silk Route, led by MIT Professor Lucien Pye. An intrepid group camped at Boston’s Logan Airport in the hopes of reaching the Virgin Islands in a raging January blizzard and were finally rewarded with warmth and sunshine many hours later. A meeting was arranged with local alumni who joined the Kenya Safari group, and an alumni group on a tour of Russia — led by MIT Professor Ernst Frankel OE ’60 — met with local alumni and key government officials in Moscow.

WILLIAM J. HECHT ’61 and members of the Association staff